DISSERTATION

Effective Capital Provision Within Government

Methodologies for Right-Sizing Base Infrastructure

Joshua C. Weed

This document was submitted as a dissertation in September 2004 in partial fulfillment of the requirements of the doctoral degree in public policy analysis at the Pardee RAND Graduate School. The faculty committee that supervised and approved the dissertation consisted of Greg Ridgeway (Chair), Bart Bennett, and Ed Keating.

RAND PARDEE RAND GRADUATE SCHOOL

The Pardee RAND Graduate School dissertation series reproduces dissertations that have been approved by the student's dissertation committee.

Published 2005 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
201 North Craig Street, Suite 202, Pittsburgh, PA 15213-1516
RAND URL: http://www.rand.org/
To order RAND documents or to obtain additional information, contact
Distribution Services: Telephone: (310) 451-7002;
Fax: (310) 451-6915; Email: order@rand.org

PREFACE

This study proposes a new, more efficient way to address a central policy problem facing the Air Force: How much capital infrastructure should the Air Force own rather than lease through other providers? The study looks specifically at an Air Force base lodging operation and evaluates policies for efficient government-owned capacity levels and contract-quarters utilization. The Air Force is currently spending $4 million per year at Maxwell Air Force Base, to house students in local hotels because of insufficient on-base capacity. Meanwhile, annual on-base occupancy figures reveal slack capacity in on-base facilities of approximately 20 percent. This dissertation examines how Air Force decisionmakers should evaluate contract-quarters usage versus occupancy rates to determine the on-base capacity that minimizes total cost. The analysis illustrates why current government metrics and methodologies are inadequate and provides an analytic approach suitable for capacity-sizing decisions in any variable-demand system. An inventory simulation model is developed that determines the least-cost inventory (capacity) and allows decisionmakers to evaluate "what-if" policy scenarios that affect lodging. The results of the research have broader implications for facility-sizing decisions within the other military services, other government agencies, and the private sector.

The research was conducted within the Manpower, Personnel, and Training Program of the RAND Corporation's Project AIR FORCE (PAF). This task is part of the Education and Training Pipeline Analysis project sponsored by General Donald Cook (AETC/CC), Lieutenant General John Hopper (AETC/CV), and Lieutenant General Roger Brady (AF/DP). The project's objective is to assist the Air Force in improving the quantity and quality of airmen trained to replenish the warfighting capability of the Air Force by better understanding the constraints that limit production and the resources necessary to relieve those constraints. The findings should be of interest to planners at Maxwell Air Force Base and AETC Headquarters, within the installation and plans offices at Headquarters Air Force, and at the Air Force Services Agency.

RAND PROJECT AIR FORCE

RAND Project AIR FORCE, a division of the RAND Corporation, is the U.S. Air Force's federally funded research and development center for studies and analyses. PAF provides the Air Force with independent analyses of policy alternatives affecting the development, employment, combat-readiness, and support of current and future aerospace forces. Research is performed in four programs: Aerospace Force Development; Manpower, Personnel, and Training; Resource Management; and Strategy and Doctrine. The research reported here was prepared under contract F49642-01-C-0003.

Additional information about PAF is available on RAND's web site at http://www.rand.org/paf.

CONTENTS

FIGURES

TABLES

SUMMARY

This dissertation outlines a new methodology that provides better estimates of an Air Force base's contract-quarters requirements, allowing more-accurate capacity-tradeoff analyses. Metrics and methodologies currently employed by the Air Force and other services underestimate the need for on-base lodging facilities by underestimating the number of contract quarters at a chosen on-base capacity. This analysis shows that a simple difference of demand and supply, even at the daily level, is a bad predictor for actual contract quarters. Beyond documenting the deficiency, this dissertation provides an alternative methodology to improve capacity right-sizing within the Department of Defense (DoD). The modeling tool developed here can also enable decisionmakers to assess the impact of various lodging policies on cost. It explores the effect of macro (on-base capacity size) and micro (lodging management) policies on lodging costs, both on- and off-base.

Looking first at the macro policy, right-sizing capital infrastructure is a difficult problem requiring more-complex analytic modeling than is currently being employed by the Air Force or the Army. On-base utilization rates are the primary managerial metric used in capacity determination by the Air Force. But these aggregate metrics do not account for important factors that affect the cost-minimizing capacity decision, such as the seasonality of demand, daily-demand variability, or the contract-quarters price. Using aggregate metrics can lead to capacity determinations that do not minimize total lodging cost. Minimizing the combined cost to the government of both on- and off-base quarters should be a leading objective in the capacity decision.

At times, the Air Force goes beyond aggregate metrics and performs formal tradeoff analyses to determine the least-cost capacity level. However, the methodologies employed in these need assessments and similarly by the Army's right-sizing model underestimate the actual contract-quarters requirement by using aggregated data and assuming too much efficiency in on-base facility utilization. Aggregating data into weekly or monthly averages conceals important phenomena occurring at the daily level,

such as demand spikes, that are essential in capacity determination. The studies also neglect on- and off-base movement restrictions and lodging's other micro policies, which enforce placement criteria that span multiple days and constrain some on-base placements. Tradeoff analyses that ignore these factors and utilize the lower off-base estimates will recommend efficient-capacity levels that are, in general, too low.

For better capacity determinations, tradeoff analysis should (1) utilize daily supply and demand data and (2) more accurately estimate the actual on- or off-base facility placements. The aggregation of daily occupancy data into monthly or annual averages is a primary reason for both the annual occupancy metrics and the needs assessments yielding incorrect capacity recommendations. The recent improved capability to export daily occupancy data from the lodging touch system (LTS) should allow future tradeoff analyses to utilize daily data and ameliorate this problem, which accounts for almost half of the understated contract quarters in our example. However, even daily data cannot fully correct the constraints created by lodging-management policies that constrain some on-base placements and necessitate contract quarters beyond those predicted by daily supply and demand alone. To correct these problems, analytic models must generate hypothetical lodging placements based on lodging's management rules, movement restrictions, course schedules, individual stay lengths, required facility types, and many other factors. Simply put, tradeoff analyses used for capacity determination must do better at estimating the actual contract-quarters requirement for a given demand pattern and chosen on-base capacity.

This dissertation outlines a tradeoff analysis that improves upon current methods. Based on the inventory-theory literature, the new methodology develops a simulation model that replicates the lodging reservation system at Maxwell Air Force Base.[1] The

[1] The inventory literature's standard daily model, which accounts for shortages by differencing supply and demand, does not sufficiently capture all shortages.

model estimates the off-base lodging requirement by accounting for course demanders whose lodging placements depend upon a list of factors spanning the lengths of their courses. Better estimates for the actual lodging placements will improve the accuracy of the tradeoff analyses. Lodging cost functions, both on- and off-base, are estimated from Maxwell's cost data and are applied to the simulation's more-accurate facility placements to generate total lodging costs. The simulation evaluates different supply capacities to determine the least-cost size of Maxwell's lodging operation for a given demand distribution.

Chapter 6 includes specific model results for our chosen case study. For FY03 demand, the efficient-capacity level required construction of two additional facilities: phase II and phase III of the Squadron Officer College (SOC) lodging plan. The Air Force is on track, having opened phase II in January 2004, and funding for phase III was appropriated in FY04. At this least-cost capacity, on-base occupancy rates are projected to be approximately 76 percent, below the 85 percent Air Force target, suggesting the deficiency of using utilization alone as the evaluation metric. The facility recommendations are contingent upon the FY03 demand distribution, and changes to demand could affect them. The growth of Maxwell's training programs since FY00 did not slow in FY04, by which time an additional 70,000 bed spaces were needed. Despite the increase in demand, the FY04 analysis recommended constructing only two additional facilities; however, construction of a third facility became a relatively more attractive policy option. Total cost estimates for constructing either two or three facilities were approximately equal, so the decision could be made on the basis of criteria other than cost. In determining efficient facility capacity, Air Force decisionmakers must determine what they believe represents a future annual demand profile, and they must evaluate their preferred construction decision against other-than-expected demand scenarios.

Apart from being a capacity right-sizing tool, the simulation is useful for estimating the effect of lodging's management policies on total cost. Strategic managerial decisions such as scheduling courses, establishing course linkages that necessitate overlap, the course-weighting scheme, and on-base/off-base movement

policies are often made with little or no understanding of the impact on total lodging cost. Up to this point, it has been relatively difficult to project the effect of these changes on lodging, due to the complexities of projecting the resulting facility placements and contract quarters. The simulation presented here provides a planning tool for estimating the impact of lodging-related policy changes by accurately projecting on-base and off-base facility placements.

Although the model was narrowly tailored to replicate several Maxwell-specific placement rules, the modeling framework is generalizable to other Air Force or DoD lodging operations. More broadly, the methodological shortcomings of right-sizing metrics (Chapter 3) are applicable to any right-sizing problem with daily demand variability, seasonality, and placement criteria that span multiple days. Acknowledging and addressing these methodological issues in current Air Force and Army models is a necessary first step. There appear to be two avenues for improving the current system of right-sizing metrics and models. The more accurate, but resource-intensive, method would be to adopt the more advanced simulation model presented in this dissertation. Alternatively, if this model is not adopted, current right-sizing methods could be improved by using daily data in future tradeoff analyses. The new capability to extract daily occupancy data from LTS should allow this added detail. However, these adjustments would not fully correct the understated contract-quarters totals, and the resulting capacity recommendations should be adjusted accordingly.

This dissertation develops a significantly more accurate means of determining the cost-minimizing number of lodging facilities at a base. It demonstrates that current managerial metrics and tradeoff analyses often will not yield this number. The simulation tool has the flexibility to be used for a variety of capital-infrastructure policy decisions, both macro (capacity determination) and micro (lodging management). It enables contract-quarters projections to be more accurate, yielding better tradeoff analyses and better informing decisionmakers of the costs of lodging.

ACKNOWLEDGMENTS

First, I would like to thank my dissertation committee: Greg Ridgeway (chair), Bart Bennett, and Ed Keating. I am deeply indebted to them for the time they committed to reviewing my work and for their thorough and helpful feedback that greatly improved the quality of the work. I thank them for bending their schedules to work within my tight timeline. I would also like to extend a special thanks to Bart, who has been a wonderful mentor since my arrival at RAND. He brought me onto my first RAND project, and I had no reason to look any further for interesting, productive work that would allow me to contribute to the Air Force. His help in focusing my chosen topic and guiding me through the dissertation process was instrumental in ensuring my three-year completion.

I am grateful to Michael Alles of Rutgers University for his very thoughtful and thorough review. He provided helpful clarifications that improved the dissertation and my thinking on the issues. He also suggested many substantive areas for future research and extensions of this work. He was an outstanding reviewer, and I would also like to thank Ed Keating for helping to arrange and facilitate his review.

I am indebted to Natalie Crawford, Craig Moore, Al Robbert, and Tom Manacapilli for providing the financial assistance and encouragement to support my dissertation. I thank them for believing that my work would result in something beneficial for the Air Force.

This analysis would not have been possible without the expertise and advice of my many Air Force contacts. I would like to thank Rhonda Goins, Chris Kitchens, Kenneth Moen, and Teresa Nihart from Maxwell lodging; Irene Pearson-Morrow, Nancy Smith, and Jackie O'Neal from the Air University registrar; John Mann from AU/XP; Terry Prudhomme, Captain Paul Swenson, and Major Mark Tharp from AETC Services; and Mike Wilson at the Air Force Services Agency.

I'd like to thank Steve Coulson of the Army's Community Family Support Center and Dean Perez at Army Forces Command for our discussions of the Army right-sizing model. This dissertation's lessons apply beyond the Air Force and could contribute to

facility planning in the other services. Thanks to my Army contacts for making that a possibility.

Thanks also to Roy Gates and Walt Hobbs for helping me convert over 20,000 pages of hardcopy data into a usable analytic format.

I cannot begin to describe my appreciation to Kristin for her patience, support, and help in making this dissertation come to life. Besides her personal support, her revisions turned a mathematical word jumble into a readable dissertation. I also must thank my parents and the rest of my friends and family for lending me the support needed to complete this work. Thank you.

ACRONYMS

ACSC	Air Command and Staff College
AEF	air expeditionary force
AETC	Air Education and Training Command
AETC/CC	Air Education and Training Command Commander
AETC/CV	Air Education and Training Command Vice Commander
AETC/SV	Air Education and Training Command Directorate of Services
AF/DP	headquarters Air Force, deputy chief of staff, personnel
AFB	Air Force base
AFI	Air Force instruction
ASBC	Air and Space Basic Course
AU	Air University
AWC	Air War College
BOT	Basic Officer Training
BRAC	base realignment and closure
COT	Commissioned Officer Training
CPD	College of Professional Development
CSAF	Air Force chief of staff
DVE	distinguished visiting enlisted quarters
DVO	distinguished visiting officer quarters
EMS	education management system
FFRDC	federally funded research and development center
FM	financial management
FY	fiscal year
GPC	government purchase card
GS	general schedule (government pay grades)
HVAC	heating, ventilation, and air conditioning
IWIMS	interim work information-management system
LTS	lodging touch system

MILCON	military construction
NAF	nonappropriated funds
NCO	noncommissioned officer
O&M	operations and maintenance
OTS	Officer Training School
PCE	professional continuing education
PCS	permanent change of station
PME	professional military education
POM	program-objective memorandum
SES	senior executive service
SNCO	senior noncommissioned officer
SOC	Squadron Officer College
SOS	Squadron Officer School
TDY	temporary duty
TLF	temporary lodging facility
VAQ	visiting airman quarters
VOQ	visiting officer quarters
VQ	visiting quarters

1. INTRODUCTION

1.1 RESEARCH OBJECTIVE

The objective of this research is to improve the utilization of facilities for Air Force training, with wider applications for facility usage throughout the Department of Defense (DoD). Insufficient capital inputs lead to constrained training production or high costs for short-term capital substitutes, while retaining excess capital infrastructure can be unproductive and costly to operate and maintain. "Right-sizing" capital infrastructure is a complex problem, requiring more-detailed analytic techniques than those currently employed by the Air Force. Forecasting and obtaining an efficient level of capital is vital to augment the Air Education and Training Command's (AETC's) training process.

Specifically, this research focuses on the lodging operation at Maxwell AFB. Maxwell's annual contract-quarters costs, defined as the expenditures for commercial lodging when on-base quarters are insufficient, have been rising over the past several fiscal years, reaching nearly $4 million in FY03. Yet annual occupancy remained just above 80 percent in FY03 and was even lower in previous fiscal years, resulting in a paradox at this aggregate level. How should a decisionmaker evaluate these conflicting pieces of anecdotal evidence, along with other pertinent information, to make an appropriate construction decision? This dissertation investigates the question of how to identify an optimal facility policy that balances the cost of maintaining excess facilities with the contract-quarters costs resulting from insufficient on-base lodging.

In answering this question, it is important to recognize that the Air Force makes both macro and micro lodging-policy decisions that affect the relative shares of on-base and off-base occupancy and thus total lodging cost. The primary focus of this dissertation is the macro policy decision of choosing the lodging operation's overall capacity size. However, micro lodging policies, which govern the operation of on-base lodging facilities, also affect on-base utilization rates and can be changed to affect lodging expenditures. Micro policies include timing of renovation and blocked spaces,

on-base/off-base movement policy, rank/gender placement separation, course weighting, course scheduling, temporary duty (TDY) reservation policy, and space-available reservation policy. This dissertation determines the efficient on-base lodging capacity (macro policy) and highlights the costs of some current lodging-management policies (micro policies) at Maxwell AFB.

More broadly, the model developed here is applicable to other right-sizing problems within the Air Force and DoD, including facility-sizing decisions in the upcoming base realignment and closure (BRAC) round, which aims to reduce support costs by eliminating infrastructure and consolidating base functions.[2]

1.2 MANAGING PRODUCTION CAPACITY

Managing production capacity and capital infrastructure is a critical component of efficient organizational management. Some economists have argued that U.S. companies maintain production capacity in excess of the level that minimizes cost, given output.[3] Increased domestic and global competition has forced companies to trim excess capacity and improve inventory management. However, determining an efficient level of capital infrastructure requires complicated models with demand forecasts that imperfectly predict the future; seasonal variability leads to uneven utilization, and capacity expansions may take many years to complete. In addition, managerial models to aid decisionmaking are often far more advanced in the theoretical literature than they are in practice.[4] Determining efficient capital levels is not unique to the private sector. DoD and other government organizations must also determine an efficient level of capital infrastructure to accomplish their missions.

---

[2] The implications of this dissertation for BRAC concern using annual-utilization rates to calculate excess capacity.

[3] Hall (1986) empirically shows that industries have chronic excess capacity and that firms are not choosing capacity to minimize expected cost under constant returns. He concludes that firms may maintain larger productive units because of economies of scale in capital acquisition or that excess capacity has other nonproduction benefits, such as deterring entry of other firms or attracting customers. An inefficient method for determining the least-cost capacity is an alternate explanation.

[4] Silver, Pyke, and Peterson, 1998, p. vii.

DoD maintains a capital stock estimated at over $600 billion in plant replacement value.[5] While this is a major investment in itself, the cost of operating, maintaining, and recapitalizing a $600 billion capital infrastructure over the life of the assets may be even greater than the up-front purchase price. Since the end of the Cold War, the military has been asked "to do more with less," highlighting the need for increased efficiency in the way DoD does business. The defense infrastructure has received attention from Secretary Rumsfeld and others as an area for significant efficiency gains: "At a minimum, BRAC 2005 must eliminate excess physical capacity; the operation, sustainment, and recapitalization of which diverts scarce resources from defense capability."[6] In 1998, a DoD analysis reported that base capacity was about 23 percent oversized.[7] Trimming base infrastructure and conducting another round of base closures in 2005 will free up significant support funds for other priorities. Eliminating unproductive capital, such as facilities with low utilization rates, is a major focus of this capital downsizing. While DoD focuses most of its attention on reducing the oversized infrastructure of a Cold War military, it must recognize that the ultimate goal is the right-sizing of capital to meet mission requirements, not just downsizing. Ensuring the productive use of capital infrastructure within DoD is vitally important for improving efficiency and the department's transformation efforts.

At a lower level, AETC's military construction (MILCON) budget is approximately $200 million per year, and its facility infrastructure is valued at an estimated $17 billion.[8] AETC is responsible for all the centralized training and education in the Air Force.[9] It is helpful to think of AETC as the manager of a complex production process, producing trained airmen for employment in the Air Force. As in all production processes, utilizing facilities and other capital infrastructure can enhance production and reduce total production costs. Facilities such as dormitories, dining halls, and classrooms

---

[5] "Facilities Recaptilization Front-End Assessment," August 2002.

[6] Secretary Rumsfeld, November 15, 2002.

[7] *The Report of the Department of Defense on Base Realignment and Closure,* 1998, p. iii.

[8] Estimate from AETC/CEPD.

[9] Training conducted in the units, referred to as on-the-job training (OJT), is carried out by the major command with direct control, not AETC.

are required for efficient training production, but at what level? Examining AETC's capital facilities helps to focus this research, while simultaneously providing a case study for methodologies and actions that could be employed throughout DoD.

To determine an efficient facility level, AETC seeks the least-cost level of capital provision to meet yearly production requirements. Ideally, the Air Force could predict capital requirements that optimize training production and could ensure that level of provision at the start of each year. In reality, future facility requirements are uncertain, capital budgets are constrained, facilities are long-term assets, and the long lead times for new-facility construction complicate the planning. All of these factors combine to make facility utilization and cost minimization, in a variety of senses, nonoptimal. Despite these limitations, AETC, like other defense organizations, must plan and work toward efficient facility usage.

At times, however, AETC faces significant capital deficiencies requiring costly workarounds. These workarounds typically fall into two broad categories: constraining production by "making do" with the current facility stock, or purchasing capital substitutes to augment production. Both the quantity and the quality of training can be constrained by facility shortages. On the quantity side, dormitories, dining halls, and classroom space limit the maximum throughput of a training course.[10] The quality of training can also be adversely affected when facilities are overtasked due to shortages. As an example, one commander argued that students' classroom performance decreased when dormitory shortages forced pipeline students to be lodged three per room, rather than the usual two.[11] Overtasking facilities also increases short-term maintenance costs and could decrease facility life because of increased wear. Conversely, unconstrained production could continue if substitutes for government-owned capital could be purchased to augment short-term production and circumvent the shortage. The benefit of this approach is that it allows flexibility in obtaining capital when needed, but on the

---

[10] Annual training production of A-10 maintenance personnel fell short every year because of dormitory constraints until the Second Air Force commander identified the problem and a new dorm was constructed (Manacapilli et al., 2004, p. 47).

[11] This anecdotal evidence was discussed in conversations with a squadron commander in 37TRG at Lackland AFB. It was not statistically determined.

downside, capital is typically more expensive on the spot market than it would be if the Air Force had purchased it in advance.[12]

When confronting a facility shortfall, AETC trades off between alternatives to otbain the most efficient workaround. One such workaround—and the focus of this research—is the use of contract quarters to supplement on-base lodging facilities. Contract quarters are alternative lodging sources, namely, nearby commercial hotels, that provide capability to meet short-term lodging demands that exceed on-base capacity. While flexible for meeting the exact lodging requirement of TDY students and other personnel, contract quarters are a more expensive per-student alternative, costing around twice as much as average on-base lodging ($55 per night vs. $20–$25 per night).[13] Because of their higher per-student costs, contract quarters presumably should be used only to supplement on-base facilities and to meet demand surges.

Contract-quarters costs at AETC bases have drawn significant attention in recent years from AETC leadership. General Cook (AETC/CC) expressed concern with contract-quarters costs at Maxwell AFB, which were found to be between $2.5 and $4 million per year from FY99 to FY03 (see Table 1.1).[14] Contract costs at Keesler AFB reached $16 million in FY03, while total contract-quarters expenditures for AETC as a whole exceeded $41 million. Despite the high utilization of off-base quarters, Maxwell's annual on-base occupancy averaged 80.4 percent in FY03 and only 74.5 percent in FY02 (see Table 1.1). On-base utilization rates are a primary metric for managing efficient facility usage, and they are used to justify or oppose future construction.

---

[12] Mattock, 2002, pp. 1, 6. Logically this makes sense, because if capital can be bought more cheaply after demand is realized, there is no reason to purchase it in advance.

[13] There are problems in using the Air Force's average cost figure because it usually does not include the cost of the building and does not represent the marginal cost of providing lodging. Typically, this figure includes total annual operating expenses divided by student throughput.

[14] Costs would have been much higher in FY03 and were projected a year earlier to be $5 million had AETC not intervened to smooth-flow some courses and to enforce movement rules bringing students back on-base when lodging became available. Lodging estimates for the cost avoidance of the movement policy alone were over $500,000 for FY03. Estimates were made using an on-base and off-base cost difference of ~ $33/bed space.

Table 1.1
Contract-Quarters Costs and On-Base Occupancy at Maxwell AFB and Gunter Annex

	FY99	FY00	FY01	FY02	FY03
Contract quarters costs ($ thousands)	2,700	3,700	3,200	3,400	3,800
Occupancy in on-base quarters (%)	80.3	75.2	76.6	74.7	80.4

NOTE: Table includes data from both Maxwell AFB and Gunter Annex. Contract-quarters costs are expressed in thousands of constant FY03 dollars.

Combining the costs of contract quarters with the 75to 80 percent utilization rates of on-base quarters yields a paradox at this aggregate level. To a decisionmaker, these two statistics form conflicting evidence on which to decide future construction policy. High contract-quarters costs argue for additional on-base facilities to trim off-base expenditures, while on-base occupancy rates reveal slack capacity in the already-owned facilities. This dissertation investigates this tradeoff and provides a methodology for determining efficient facility capacity.

1.2 ORGANIZATION OF THIS DISSERTATION

Chapter 2 provides background information on the Air Force lodging operation, with particular emphasis on Maxwell AFB. Chapter 3 reviews alternative methodologies used by the Air Force and the Army for determining the efficient on-base facility level, highlights the need for a more-detailed approach by explaining why current metrics are insufficient, and proposes an inventory-theory approach. Chapter 4 reviews the inventory-theory literature and applies that literature to the Air Force lodging-capacity problem by describing a new simulation approach for determining the efficient number of lodging facilities (macro policy) that can serve as a tool for evaluating the costs of some micro lodging policies. Chapter 5 describes the simulation model in detail, including the estimation methodology for determining demand and costs. Chapter 6 analyzes the model results and recommends an efficient capacity size for Maxwell AFB's lodging

operation. Chapter 6 also includes sensitivity analyses to evaluate the model results to varying input parameters. Chapter 7 illustrates the use of the simulation model as a tool for evaluating the costs of lodging-management policies, and Chapter 8 summarizes and concludes. Supporting information is contained in five appendices, which are referenced in the appropriate sections of the text.

2. THE AIR FORCE LODGING PROGRAM

This chapter provides general background information on the Air Force lodging program. After a short general overview, the discussion focuses on Maxwell AFB's lodging operation. It discusses both the supply of lodging facilities and the complexities of the demand makeup at Maxwell.

2.1 AIR FORCE LODGING PROGRAM

The Air Force lodging program, governed by Air Force Instruction (AFI) 34-246, "provides quality lodging facilities and service to authorized personnel to maintain mission readiness and quality of life, while keeping official travel costs to a minimum." In other words, base lodging is intended to provide convenient, standardized lodging for military personnel on temporary government travel and is less costly than nearby commercial accommodations. We identified three reasons for the lower costs of government quarters:

- Land cost is typically not included because facilities are built on already-owned land.
- Government quarters do not include commercial amenities such as swimming pools, exercise rooms, or free continental breakfasts.
- Economies of scale reduce the per-room price because fixed costs such as those for reservations staff or desk clerks are spread across a larger operation.

AFI 34-246 delineates the personnel eligible to use Air Force lodging's visiting quarters and their associated priority for lodging.[15] AFI 34-246 broadly divides lodging demand into two priority categories: priorityone and prioritytwo. Simply stated, priority-one demands are generally guaranteed rooms either on- or off-base, whereas priority-two demands are met on a space-available basis. The relevant category for the purpose of this

---

[15] Examples include military TDY, permissive TDY, active duty on emergency leave, guests of the installation, family members on medical TDY orders, and Reserve and Guard personnel on annual tours or in per diem status.

dissertation is priority-one demand, the largest of which is "military or DoD civilians on temporary duty (TDY) to the installation."

AFI 34-246 further dictates that "Air Force temporary duty personnel must use on-base lodging when adequate and available (unless waived for military necessity), and will make advance reservations when traveling to an Air Force installation." The Air Force mandates these practices to minimize overall government travel cost and encourage on-base utilization. It seeks alternative commercial lodging only after on-base facilities are occupied or reserved.

When on-base quarters are unavailable for priority-one personnel, the lodging operation arranges alternative commercial lodging.[16] AFI 34-246 instructs that "Air Force lodging operations, in conjunction with the local base contracting office, will attempt to negotiate reduced rates for commercial lodging accommodations in order to provide eligible guests alternative lodging when adequate on-base lodging is not available."[17] These accommodations are known as contract quarters because the base lodging operation maintains contracts with off-base hotels to offer rooms at below-market rates. When both on-base lodging and contract quarters are unavailable, travelers are issued a nonavailability number authorizing them to find alternative civilian accommodations with the help of the base lodging operation.[18]

Once personnel are placed in contract quarters, they generally remain off-base; movement back to base is voluntary, according to AFI 34-246. However, the AETC supplement to AFI 34-246 implements a stricter movement policy at AETC bases, requiring students to move on-base when space becomes available.[19] According to the AETC supplement, "Managers must maximize the use of on-base lodging. This means

---

[16] Eligibility for commercial lodging is defined in the eligibility tables in AFI 34-246 for each demand category. Most, but not all, priority-one demanders are eligible for commercial lodging. For simplicity, it is important to know that TDY personnel, accounting for the majority of the demands, are eligible for commercial lodging if on-base facilities are unavailable.

[17] AFI 34-246, section 2.2.5.

[18] Nonavailability numbers give personnel the authority to seek out their own accommodations at the government's expense; however, government per diem rates still apply.

[19] Major commands (MAJCOMs) can supplement some Air Force instructions, creating policies relevant to operations within their purview.

that managers may require students to be lodged both on- and off-base during the course of their TDY, provided students are *only moved once* and *the length of stay in both locations is at least 5 days*"[emphasis added]. This establishes a separate policy at AETC bases to minimize usage of commercial lodging and delineates a very specific movement policy to be implemented by lodging reservation managers. At Maxwell, this policy was credited with saving over $500,000 in off-base charges in FY03.

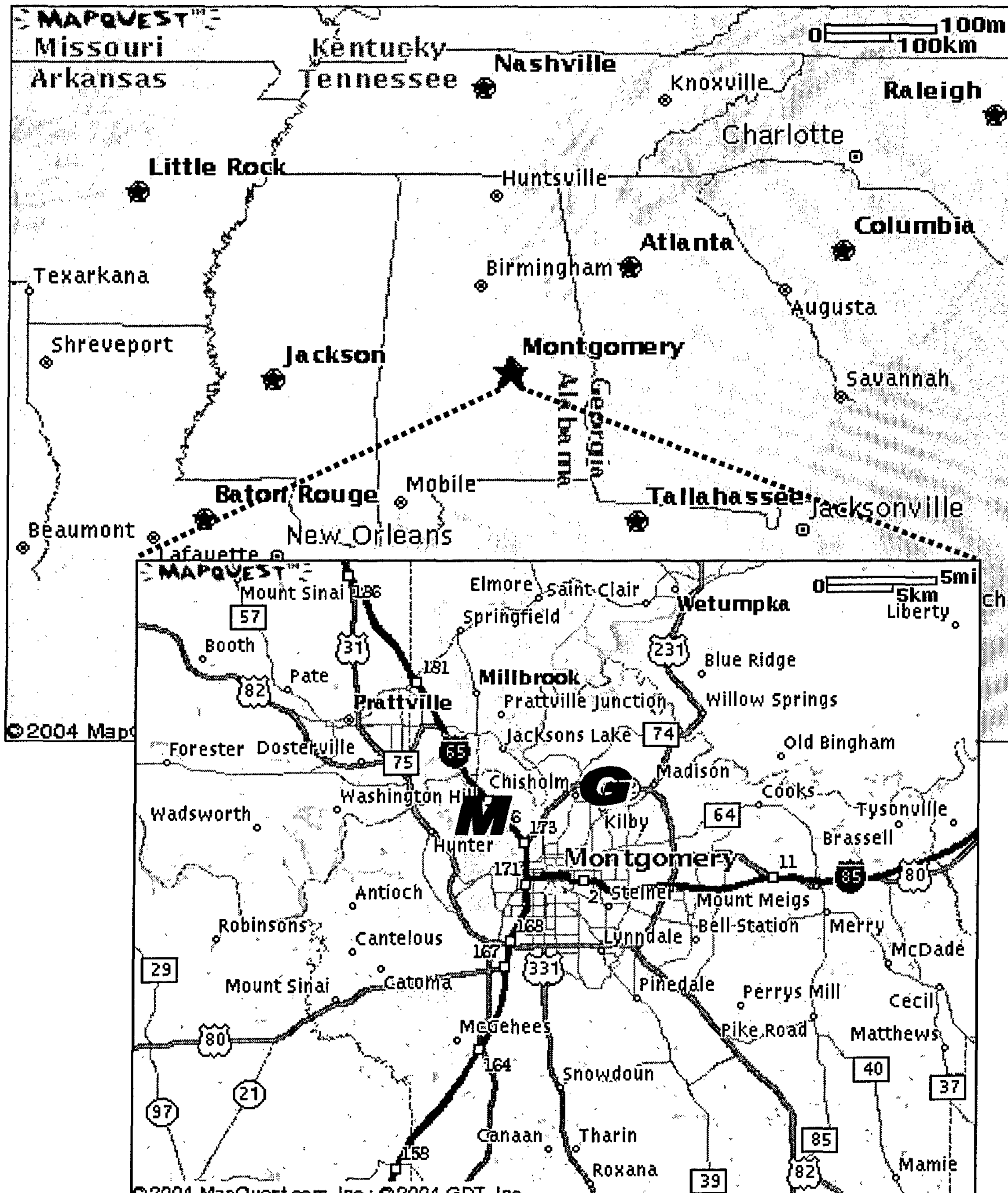
There are several different types of on-base lodging: distinguished visiting officer quarters (DVO), visiting officer quarters (VOQ), enlisted suites for distinguished enlisted (DVE), visiting airman quarters (VAQ), and temporary lodging facilities (TLF). The distinctions between the first four facility types are in the size and amenities offered based on the intended occupant's rank. TLFs, however, are a separate class of facilities primarily intended to house personnel and their families who are making a permanent change of station (PCS) to the installation, i.e., being reassigned, until permanent housing is found. This analysis does not include TLF data, since these facilities are predominantly used for PCS personnel, and this study focuses on the TDY requirement. In the interest of maximizing occupancy, lodging operations have, on rare occasion, used vacant TLFs for lodging TDY personnel, especially small groups. However, such cases are infrequent, so excluding the TLF data will not significantly affect the TDY lodging analysis.

AFI 34-246 governs the minimum space and privacy standards by Air Force rank, thereby dictating the type of room needed to accommodate particular personnel. To minimize commercial lodging utilization, guests are assigned to available rooms that meet or exceed the minimum adequacy standards, primarily meaning that enlisted personnel can be placed in VOQ. Officers may also be assigned to VAQs when the VAQ meets minimum adequacy standards for officers.[20] For uniformity, the Air Force is moving to a new standard for visitor quarters (VQ), eliminating the officer-enlisted distinction.

[20] AFI 34-246, Chapter 2, Table 2.1.

2.2 MAXWELL–GUNTER AFB

Maxwell Air Force Base and Gunter Annex are located in Montgomery, Alabama. The two locations are co-identified as one base—Maxwell-Gunter AFB—or sometimes just Maxwell AFB. Gunter Annex supports the academic mission of Maxwell and is located approximately seven miles northeast of Maxwell proper (see maps in Figure 2.1). For the remainder of this dissertation, including data and charts, the two bases will be jointly referred to as Maxwell AFB, unless the discussion specifically refers to one site. Maxwell AFB is home to Air University (AU), the center for advanced education in the Air Force, and the base's primary organization. The mission of AU will be described further in Section 2.4.



2.3 MAXWELL AFB LODGING SUPPLY

The Maxwell lodging complex comprises more than 40 buildings with more than 2,000 rooms, making it one of the largest base lodging operations in the Air Force.

Supply is defined as the number of on-base bed spaces to satisfy lodging requirements. However, there are two ways to measure this supply: total bed spaces and available bed spaces. Total bed spaces count the entire stock of rooms within all base facilities, and available bed spaces are derived by subtracting the number of blocked bed spaces from the total bed spaces. Blocked bed spaces are predominantly the result of scheduled or unscheduled maintenance, which makes a room unavailable for occupancy. Available bed spaces is the best supply measure, since it incorporates the impact of blocked spaces, thereby more accurately representing the supply available to meet demands. While available bed spaces is the supply variable of interest, Air Force managers can affect available supply only indirectly, using the two key policy levers, total bed spaces and facility-maintenance policies that affect blocked spaces. The supply discussion below focuses on total and blocked spaces separately, then considers how they jointly determine available space.

2.3.1 Total Space

Total space is a direct function of the total number of facilities. Table 2.1 delineates lodging supply at Maxwell and Gunter separately, by base, room type, and facility. It also presents totals by facility type (DVO, DVE, VOQ, and VAQ) and base. It is important to note the distinction between facility-type identifier in the first column and lodging-touch-system (LTS) [21] identifier in the second. Both identifiers are used to classify the facility's room type. The first column is the broad facility type as defined in Section 2.1 according to the rank of the intended occupant. LTS, however, creates an additional distinction in classifying room types within these broad categories. This analysis uses LTS occupancy data and the associated classification system, thereby allowing for greater analytic detail than do the broader facility-type designators. Consequently, in most cases, supply and occupancy phenomena can be tracked at the individual facility level, rather than by broad facility type. In some cases, LTS aggregates similar facility types into a single category, such as Maxwell's eight facilities

[21] LTS is the computer system used by lodging management to track reservations and occupancy.

with shared bathrooms (designated ORM1S) or Gunter's three VOQ facilities (ORM1P). For these, LTS occupancy data cannot be disaggregated, and the analysis is performed using combined facility data.

Table 2.1 presents the facility supply listing used later in the simulation analysis. One significant caveat concerns building 681, which opened in January 2004 and is included under Maxwell's VOQ facilities. The baseline supply (starting point) for this analysis is those facilities available during FY03. Therefore, building 681 is omitted from the baseline case, but the model considers the effect of additional facilities on contract quarters, starting with building 681 and including future planned construction.

Table 2.1
Facility Listing – Total Space

Base/Facility Type	LTS Identifier	Building Number	Number of Rooms
Maxwell/DVO	ODV1P	119	15
	OGN1P	119	1
	OST117	117	9
	OST121	121	9
	OST142	142	12
	OST143	143	12
	OST157	157	4
	OST 680	680	13
Total			**75**
Maxwell/DVE	EDV1P	697	5
	EST1P	695	6
Total			**11**

Maxwell/VOQ	SQ157	157	78
	SQ679	679	152
	SQ680	680	87
	SQ699	699	72
	SQ1417	1417	40
	SQ1418	1418	40
	SQ1419	1419	39
	SQ1422	1422	16
	SQ1428	1428	49
	SQ1429	1429	49
	SQ1468	1468	40
	SQ1470	1470	40
	ORM1S	695	56
	ORM1S	1413	82
	ORM1S	1416	80
	ORM1S	1430	82
	ORM1S	1431	80
	ORM1S	1432	82
	ORM1S	1433	82
	ORM1S	1434	82
	ORM1P	681[a]	162
Total		**FY03**	**1,328**
		FY04	**1,490**
Maxwell total		**FY03**	**1,414**
		FY04	**1,576**
Gunter/DVO	OST503	1503	37
	OST872	872	4
	OST873	873	7

	OST874	874	2
Total			**50**
Gunter/DVE	EDV1P	1015 & 1017	3
	EST1P	1015	8
Total			**11**
Gunter/VOQ	ORM1P	872	40
	ORM1P	873	21
	ORM1P	874	30
Total			**91**
Gunter/VAQ	ERM1S	1014	90
	ERM1S	1015	54
	ERM1S	1016	90
	ERM1P	1015	1
	ERM1P	1017	249
Total			**484**
Gunter total			**636**
Maxwell-Gunter total		**FY03**	**2,050**
		FY04	**2,212**

[a] Building 681, phase II of the Squadron Officer College (SOC) lodging plan, opened in January 2004.

Limited lodging supply has been a concern at Maxwell dating back at least to a briefing in FY01, "AU-21: Air University's Production Challenges." This briefing outlined capacity constraints in nearly all of AU's critical mission programs. At that time, the Officer Training School (OTS) campus at Maxwell was used only for Basic

Officer Training (BOT) and had facilities for 1,000 graduates per year.[22] FY02 production requirements then climbed rapidly to 1,900 for BOT and 2,027 in Commissioned Officer Training (COT) at Gunter, totaling 3,927. These increases stressed OTS campus facilities at Maxwell and lodging assets at Gunter. The requirement for Air and Space Basic Course graduates rose from 1,600 in FY01 to 4,800 in FY02. The Air Force requirement for Noncommissioned Officer (NCO) Academy graduates jumped from 7,000 in FY01 to 11,000 in FY02, surpassing Air Force-wide capacity, which was less than 8,000 at the time. This increase led to the creation of the NCO Academy at Gunter Annex, fortunately timed with COT's move to the Maxwell OTS campus. The Air Force's increased training requirements shifted a heavy production burden onto AU and Maxwell's facility infrastructure. Supply changes, including the completion of several MILCON projects,[23] are just beginning to catch up, but are they now properly sized? What is the efficient supply infrastructure to manage Maxwell's training courses?

Over the past several years, Maxwell's base lodging operation has tried to increase its amount of total space. Buildings 695, 697, and 699 were originally permanent-party[24] enlisted dormitories, but they have since been partially or wholly converted into lodging rooms. Along with the conversion from dormitory to lodging facilities, buildings 695 and 699 were redesignated as VOQs to allow for officer occupancy, since officers generate the majority of base demand and enlisted personnel can stay in VOQs. In

---

[22] Commissioned Officer Training (COT) was located at Gunter annex until FY03, when it moved to Maxwell's upgraded OTS campus.

[23] MILCON projects included a 120-room OTS dormitory completed in FY02, an OTS academic addition completed in FY03, a 120-room OTS dormitory programmed in FY02 for completion in FY04, renovations to buildings 1430 and 1431, new construction of building 681, and SOC phase III, appropriated for FY04.

[24] Permanent-party dormitories are intended for enlisted personnel assigned to the base, not transient training personnel.

addition, many lodging facilities do not meet current Air Force standards for VQs.[25] While replacing these "substandard" facilities is desirable, the primary focus has been on maximizing available rooms, necessitating the continued use of these facilities. Once concerns over insufficient facility space are resolved, decisions on upgrading, replacing, or demolishing substandard facilities will become an important consideration in the overall efficient lodging inventory.

Future construction of Maxwell's lodging facilities is outlined in the SOC lodging plan developed during the late 1990s. This plan calls for construction of an SOC campus that will include phased construction of six additional lodging facilities (phase II through VII) in close proximity.[26] Along with building 679 (phase I) and building 680, both of which opened in 1992, the campus will contain eight lodging facilities totaling more than 1,200 rooms. Phase II opened in January 2004. Phase III received congressional appropriation in FY04 and will begin construction soon. The next phases are already designed, awaiting the funding decision. Determining an efficient level for Maxwell's lodging facility inventory, which may include future phases of the SOC lodging plan, is a primary objective of this dissertation. Understanding efficient facility levels provides analytic support to help guide investment decisions in future phasing of the SOC lodging plan. Table 2.2 details the remaining phases of that plan.

---

[25] The majority of these "substandard" dormitories are designated as such due to their configuration as shared-bath rooms, a standard discontinued by the Air Force. However, some facilities are designated substandard due to their current state. The lodging headquarters known as University Inn, building 157, suffers from mold and rot due to the poor HVAC system as well as other problems, such as corroding pipes, associated with the age of the building (built in 1969) and the date since the last major renovation (1990). Replacing the University Inn was one of AU's top six MILCON priorities in the FY05 MILCON program call.

[26] Building 679 was already complete and designated phase I of the SOC campus.

Table 2.2
Facilities to Be Built in Remaining Phases of the SOC Lodging Plan

Base/Facility Type	LTS Identifier	Phase	Rooms
Maxwell/VOQ	ORM1P	III[a]	162
	ORM1P	IV	162
	ORM1P	V	162
	ORM1P	VI	162
	ORM1P	VII	162
Total			**810**

[a] Phase III received congressional appropriation in the FY04 budget.

2.3.2 Blocked Spaces

To determine the supply of rooms available for occupancy, blocked spaces must be subtracted from total space. Blocked spaces are rooms unavailable for occupancy for a variety of reasons. Predominantly, they result from scheduled and unscheduled maintenance, but spaces can also be blocked, for example, to allow late checkout for personnel attending a course that ends late in the day or because the maid service is not able to make up all the rooms. Major renovations and scheduled maintenance block a large number of rooms, often entire facilities, but the timing of these blockages is usually somewhat flexible. Consequently, scheduled blockages are completed during low-demand periods, such as over the Christmas holiday, around the 4th of July, and near the end/beginning of the fiscal year. These are historically periods of low demand, when facilities can be blocked without a costly shift of demand to off-base quarters. Figure 2.2 shows the total number of blocked spaces at both Maxwell and Gunter throughout FY03.

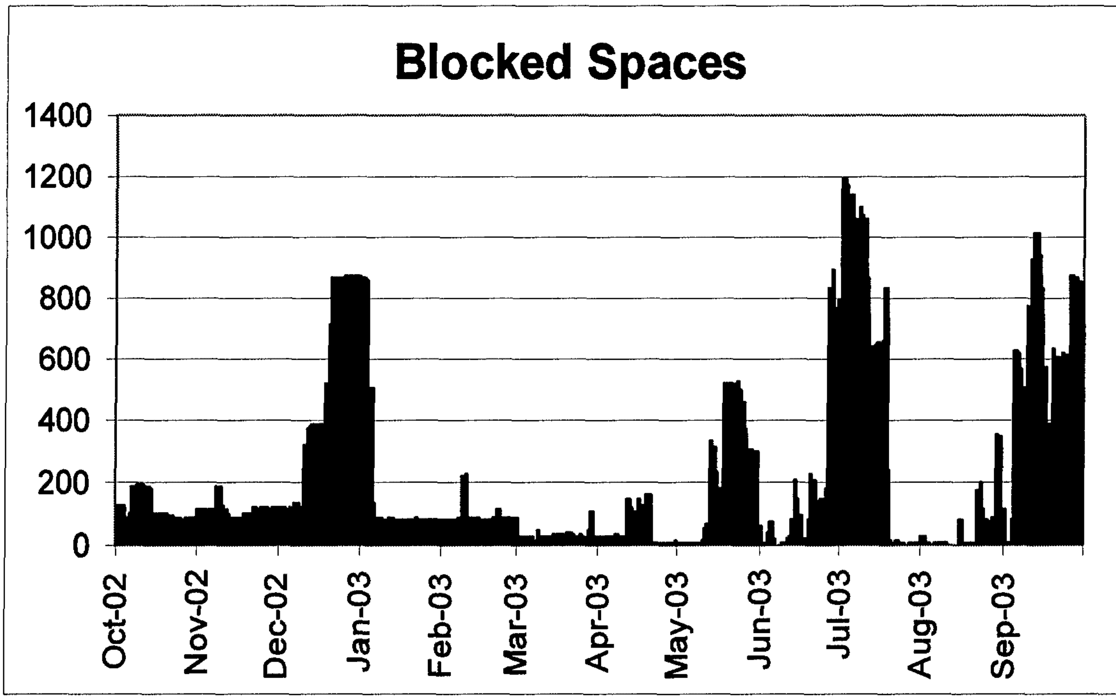


Figure 2.2 – Total Blocked Spaces at Maxwell and Gunter in FY03

While the majority of blocked spaces are the result of schedulable renovations or maintenance, some fraction result from less-predictable fluctuations, such as unexpected maintenance problems that restrict occupancy. When planning the number of rooms available for occupancy throughout the year, it is important to take into account the large scheduled blockages, but modeling the random fluctuations is equally important, since they occur independent of demand (i.e., they cannot be timed) and will therefore have a more direct impact on the need for contract quarters. Chapter 5 discusses this concept in more detail, provides a methodology for disaggregating the two causes of blocked spaces from the data, and describes the modeling approach for each piece. For now, it is important to understand the general concept of blocked spaces, the reasons they occur, and how they are combined with total space to derive available space.

2.3.3 Available Space

Available space is the most complete supply measure and is most useful in facility planning. The Air Force's direct policy levers to affect supply are (1) increasing total

space through additional construction or facility redesignation, and (2) lodging policies that affect blocked spaces.[27] Figure 2.3 shows the total space in FY03 (2,050 rooms) and the blocked spaces from Figure 2.2, yielding available space (the shaded area).

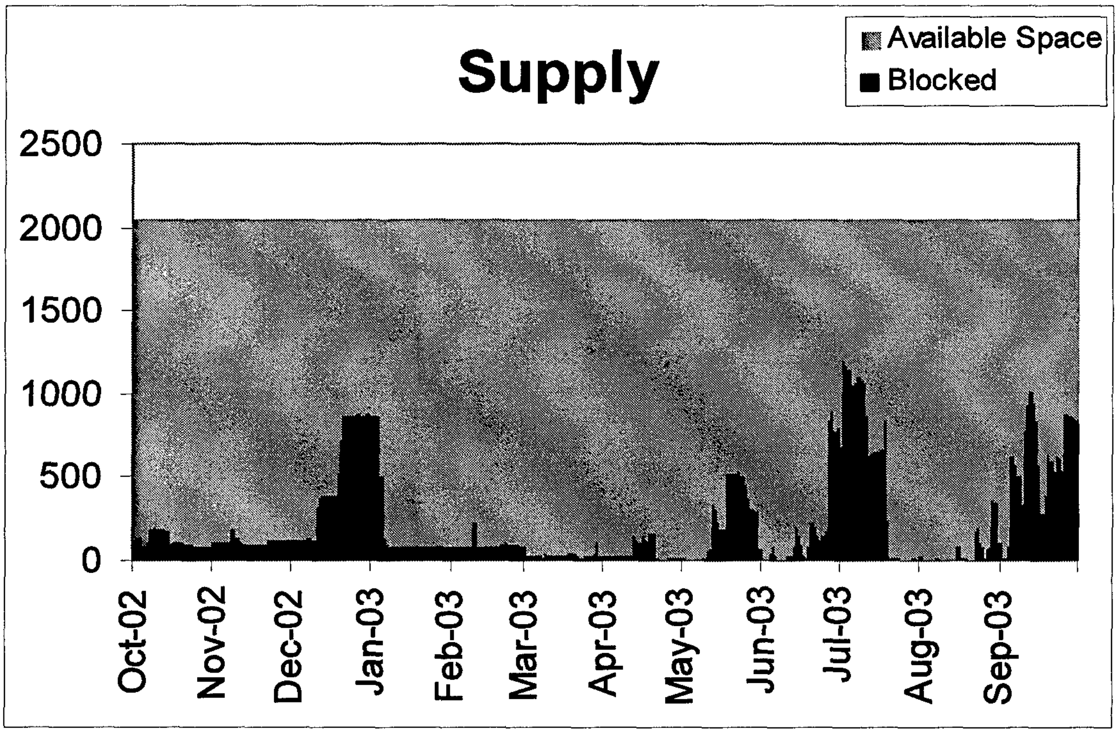


Figure 2.3 – Lodging Supply at Maxwell and Gunter in FY03[28]

This section has provided general background about the current state of supply at Maxwell and definitions of the concepts of total space, blocked space, and available space to clarify future references and data. Chapter 3 presents a more detailed analysis of daily supply and demand data for FY03.

---

[27] Lodging policy refers to those blockages where lodging controls the number and timing of blocked spaces, e.g., for scheduled maintenance or renovations. Unexpected blocked spaces are generally uncontrollable by Air Force lodging policies, except perhaps indirectly through the overall state of facility repair that affects breakage rates.

[28] This data series ends in September 2003. Consequently, the completion of phase II (building 681) in January 2004 and the resulting supply spike of 162 rooms do not appear in this figure.

2.4 MAXWELL AFB LODGING DEMAND

As noted earlier, Maxwell is home toAU, "the Air Force's center for professional military education." AU conducts academic curricula in aerospace studies, graduate education, and professional continuing education for officers, enlisted personnel, and civilians in preparation for command, staff, leadership, and management assignments."[29] The SOC, NCO academies, other AU courses, and base functions bring a large inflow of TDY students to Maxwell. More than 80,000 students and travelers come to Maxwell each year, imposing a sizable requirement (demand) for on-base lodging. On-base facilities at Maxwell provide more than 500,000 bed nights to meet that demand, making it one of the largest lodging operations in the Air Force. Further, demand has been growing over the past several fiscal years, corresponding to the growth of AU programs (see Table 2.3).

Table 2.3
Maxwell's Annual Lodging Demand

	FY00	FY01	FY02	FY03
Total on-base bed spaces	383,000	427,200	510,000	532,000
Total off-base bed spaces	61,400	50,500	56,800	69,000
Total demand	444,400	477,700	566,800	601,000

NOTE: Computed from occupancy data for both Maxwell and Gunter, excluding TLF.

AU courses provide the vast majority of demand for Maxwell's lodging facilities. Courses requiring lodging are listed in the registrar's course database, EMS.[30] In FY03,

[29] *Maxwell AFB General Plan*, n.d., p. 8.

[30] The EMS database also includes groups not directly associated with AU courses, such as: Guard and Reserve drill weekends, Air Force band performances, Junior Reserve Officers' Training Corps (JROTC) visits, and weddings. The AU registrar consolidates lodging requests into a centralized database to help manage lodging. EMS is discussed in more detail in subsection 2.4.1.

roughly 90 percent of the total demand for on-base lodging was captured in the EMS lodging request inquiry. AU's course listing is too extensive to describe here, but it is presented in its entirety in Appendix A. As a general framework, courses are separated into major categories according to course content and purpose:

- **Professional military education (PME).** For both commissioned officers and NCOs, PME programs educate airmen on the capabilities of aerospace power and its role in national security. Examples include SOC, the Air Command and Staff College (ACSC), the Air War College (AWC), and the NCO academies.
- **3-, 5-, and 7-level technical training.**[31] Technical training, given in AU's College of Professional Development (CPD), provides initial and follow-on training in an enlisted career specialty, such as chaplain assistant, historian apprentice, or historian craftsman.
- **Professional continuing education (PCE).** PCE programs provide scientific, technological, managerial, and other professional expertise to meet the needs of the Air Force. Examples include academic instructor courses, the manpower staff officer course, judge advocate courses, and the professional military comptroller course.
- **AU scheduled seminars and workshops:** AU hosts many leadership meetings, academic exercises, seminars, war games, and workshops. Examples include the national security forum, senior executive service (SES), Air and Space Power Seminar, GS15 leadership seminar,[32] and military judge's seminar.

---

[31] Chapter 2 of Dahlman, Kerchner, and Thaler, 2002, defines enlisted skill proficiency levels (i.e., 3-, 5-, and 7-level).

[32] GS (general schedule) is the acronym used to designate civilian government-employee pay grades.

The AU registrar publishes an annual course catalog describing in detail each school and course, along with general information on AU. The catalog is available online at http://www.au.af.mil/au/catalogs.php.

The SOC administers the two largest courses, SOS and the Air and Space Basic Course (ASBC). When both courses were in session in FY03, they accounted for a combined total of 1,000 students, roughly 400 and 600, respectively.[33] This large number of students taxed Maxwell's (*Maxwell only*) 1,328 VOQ rooms in FY03, leaving little extra on-base capacity to house other demands in these periods. To illustrate this point, during FY03, both SOC and ASBC were jointly in session less than half of the year, 171 of the 365 days. On these 171 days, 47,000 of the 69,000 (68 percent) total contract quarters occurred, an average of 275 per day. On all other days, including days when only one of the courses was in session, contract quarters averaged only 110 per day. While possibly difficult to execute, further separation of these two course schedules would reduce demand surges and could sharply reduce the number of contract quarters. Figure 2.4 highlights the impact of ASBC and SOS on the overall demand picture.

[33] Changes to ASBC for FY04 have increased the number of students in each class from 640 to 840.

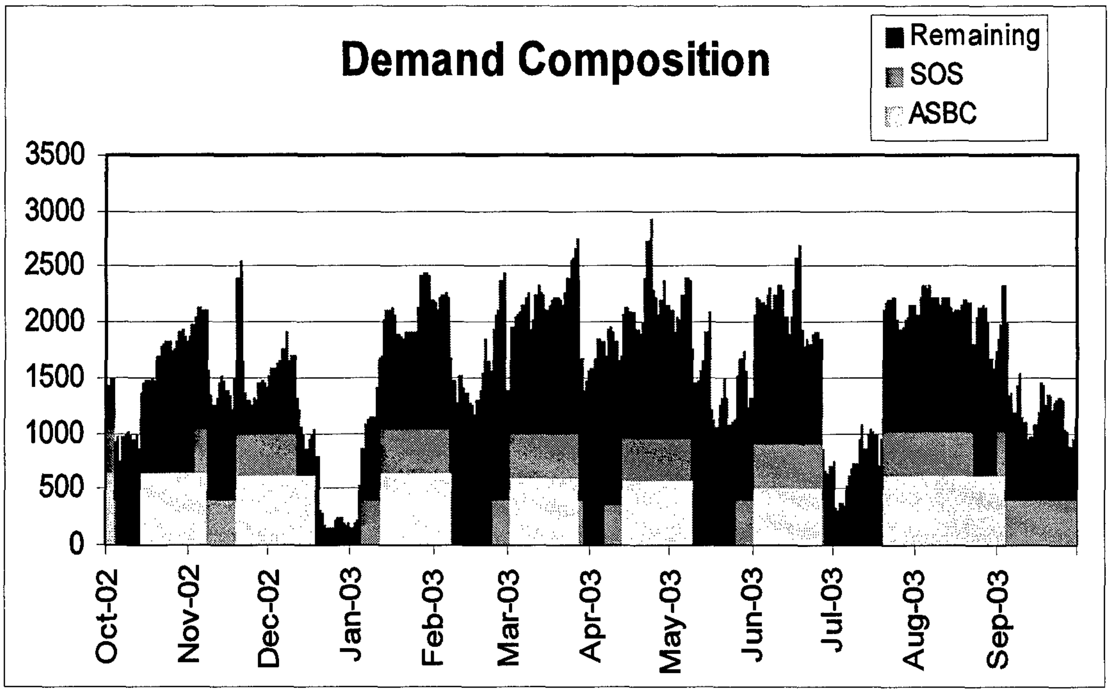


Figure 2.4 – ASBC and SOS Contribution to Overall Lodging Demand at Maxwell and Gunter in FY03

When discussing the effects of courses on demand for lodging, it is important to make a distinction between the AU's TDY courses that impose lodging requirements and those that do not rely on base lodging to house students.[34] Apart from the limited number of international students, students in PCS courses such as AWC and ACSC are required to find their own off-base housing. Additionally, with the recent transfer of COT from Gunter to the OTS campus at Maxwell, OTS now provides its own dormitories to house both BOT and COT, unless overflow requires lodging facilities. Consequently, lodging-demand figures exclude the AU courses that do not impose a lodging requirement.[35]

---

[34] This is not to say that these courses or schools won't have similar infrastructure sizing problems, such as sizing dormitories for the OTS campus. However, those problems are independent from the issue analyzed here, since they do not utilize base lodging. The Air Force could decide to consolidate resources (lodging facilities and dormitories) under a single manager, which could improve joint efficiency, but that analysis is beyond the scope of this dissertation.

[35] Before COT moved to the OTS campus at Maxwell in FY03, COT students were lodged at Gunter. Some FY03 courses occurred before the move and are included in the demand analysis.

Only AU courses requesting lodging in the EMS are included in the course-demand model.[36]

The majority of courses are conducted at Maxwell proper, while Gunter Annex is host to the NCO Academy, SNCO Academy, and a short list of other courses, mostly for enlisted personnel. Consequently, Maxwell and Gunter have very different demand patterns corresponding to their on-base missions and courses. At Maxwell, most of the lodging demand occurs in conjunction with AU's officer programs and is met by the base's high proportion of VOQs. Of Maxwell's roughly 360,000 on-base lodging occupants in FY03, 97 percent stayed in VOQs.[37] Lodging requirements at Gunter Annex are driven by the NCO academies, and the majority of base demand is met by VAQs. Of Gunter's roughly 170,000 on-base lodging occupants in FY03, 72 percent stayed in VAQs.[38] As a result, the key lodging types, as seen in Section 2.3, are VOQs at Maxwell and VAQs at Gunter. Although the two locations are about seven miles apart, they are considered one lodging operation with interchangeable facilities and one central reservation system. Courses express their base preference, and lodging's reservation staff tries to satisfy course desires, but when shortages occur at a course's preferred location, available lodging at the alternate location is utilized before off-base hotels are sought.

As stated, AU courses supply roughly 90 percent of priority-one demand. The remaining demand comes from entities not required to register in EMS: Army courses, some Guard and Reserve drill units, ordinary TDYs to Maxwell, and groups of fewer than 10 students.[39] As at other Air Force bases, lodging provides accommodations at Maxwell for nonstudent TDY personnel conducting base business. Since little information is known about the individuals making up the remaining 10 percent of

---

[36] Lodging demands not specified in EMS are not excluded from the overall analysis. They are aggregated and included separately from the course-demand model. Representing demand will be discussed in Section 2.3.1.

[37] This does not mean that they were all officers, since enlisted personnel commonly stay in VOQs. Nearly all facilities at Maxwell are designated VOQ to allow occupancy by officers or enlisted personnel.

[38] Again, this fraction does not exactly represent demand share, since enlisted personnel stay in Gunter VOQs when VAQs are full.

[39] EMS captures many of these small groups.

demand, this analysis combines them into a single category called "residual demand." Figure 2.5 displays daily demand data for on-base lodging at Maxwell and Gunter for FY03, highlighting the two major categories of demand. The residual demand accounts for the difference between actual priority-one occupancy and the course demands from EMS. Subsection 2.4.1 discusses how this analysis tabulates demands in each category from available databases.

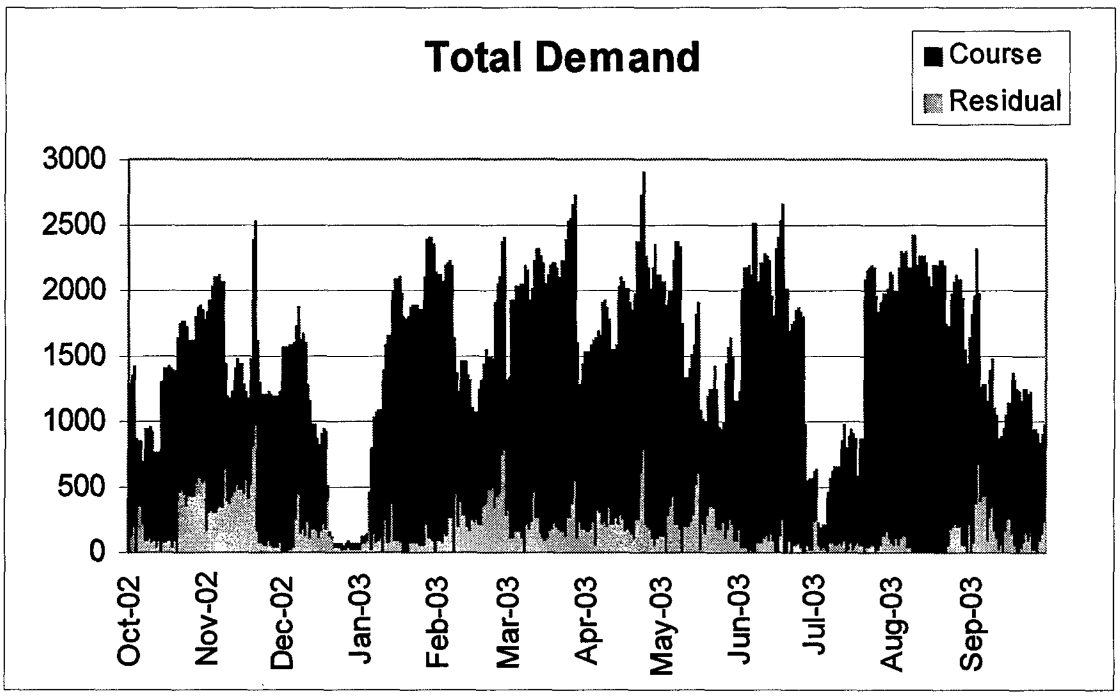


Figure 2.5 – Total Lodging Demand at Maxwell and Gunter in FY03

Figure 2.5 clearly shows the high- and low-demand periods, which predominantly result from course scheduling. Fewer courses are scheduled near federal holidays, especially Christmas and the 4th of July, because of the lost training days associated with these holidays. For the most part, schools set their own schedules, with little or no consideration for overall lodging demand. Other scheduling constraints such as instructor availability and preparation, AEF cycles, holiday avoidance, summer PCS cycle, joint course curricula requiring overlap, and avoiding course schedules that extend

over two fiscal years usually take priority over lodging.[40] While many of these scheduling constraints should continue to take priority over lodging, ensuring the transparency of lodging costs will assist decisionmakers in evaluating scheduling tradeoffs. The registrar's office currently aggregates course schedules and suggests changes in start dates to schools with lower-priority courses in an effort to improve aggregate scheduling efficiency, but these moves appear to be voluntary. There is no overall authority above the schools to weigh all scheduling considerations (including the effect on lodging) or to force changes in the interest of reducing off-base costs. The authority to ultimately schedule courses resides with the individual schools, where the effects of scheduling decisions on lodging costs are generally not considered or even known.

2.4.1 Representing Demand

Representing demand can be complicated, since there are multiple facility types (DVO, DVE, VOQ, VAQ, and TLF), multiple sites (Maxwell and Gunter, in this case study), and no database that exactly tabulates demand in sufficient detail. As mentioned, this analysis eliminates TLF data to focus on TDY demand, and it consolidates Maxwell and Gunter data, since the two sites are operated as a single entity. Lacking a central demand database that includes all demands and their composition, this analysis combines data from two sources (EMS and LTS) to estimate the composition of overall lodging demand.

EMS provides two lodging-related functions, which record a comprehensive listing of all courses requesting on-base lodging: the lodging-availability output report and the lodging-request inquiry. The lodging-availability output report is a tool used to manage aggregate lodging supply and demand information. It consolidates all course-related lodging demands for each day and compares this aggregate sum with the total number of lodging rooms. It highlights for rescheduling high-demand periods when excess capacity is low and lodging shortages could occur. While useful as a managerial

---

[40] Joint curricula of SNCO Academy and ASBC now require course-scheduling overlap.

tool, excess-demand measures (demand-supply) have shortcomings as predictors of the number of contract quarters (discussed further in Chapter 3). Consequently, the lodging-availability report, shown in Figure 2.6, is most useful as an aggregate planning tool to deconflict course schedules, not as a predictor of contract quarters.

Lodging Availability Summary

Combined Gunter and Maxwell Locations

Initial		31-Oct-02	1-Nov-02	2-Nov-02	3-Nov-02	4-Nov-02	5-Nov-02	6-Nov-02
	Officer	1338	1338	1338	1338	1338	1338	1338
	Enlisted	470	470	470	470	470	470	470
Totals	Total	1808	1808	1808	1808	1808	1808	1808
Projected		**31-Oct-02**	**1-Nov-02**	**2-Nov-02**	**3-Nov-02**	**4-Nov-02**	**5-Nov-02**	**6-Nov-02**
	Officer	1066	1221	1159	1642	1559	1559	1557
	Enlisted	237	613	553	601	275	275	245
Totals	Total	1303	1834	1712	2243	1834	1834	1802
Available		**31-Oct-02**	**1-Nov-02**	**2-Nov-02**	**3-Nov-02**	**4-Nov-02**	**5-Nov-02**	**6-Nov-02**
	Officer	272	117	179	-304	-221	-221	-219
	Enlisted	233	-143	-83	-131	195	195	225
Totals	Total	505	-26	96	-435	-26	-26	6

NOTE: The three groupings are the supply of lodging rooms (initial), the summed course demands (projected), and the difference between the two (available). Each grouping includes officer, enlisted, and totals by day. Actual EMS output is abridged for clarity.

Figure 2.6 – EMS Lodging-Availability Report

The lodging-request inquiry, EMS's second lodging function, transfers course schedules and projections into reservation-request format. The lodging-request inquiry is the online medium by which a course's lodging requirements are passed from the schools via the registrar to the lodging reservation system. The database includes all course information required to make reservations, including course weighting, class start and end dates, projected students by rank category, and base and/or facility preferences. Figure 2.7 presents three sample records from FY03. For illustration, the first record is the 3-level chaplain service support course (M3ABR5R031), with an on-base weighting factor of 59. It is the course's first offering of the fiscal year (03A) and is located at

Maxwell AFB. The course is scheduled to begin October 6, 2002, and end November 15, 2002; there are 30 projected enlisted attendees.

Lodging Request Inquiry

	Course Information		Class Information				Projected Lodging		
Weight Factor	Course ID	Course Title	Class ID	Class Location	Arrival Date	Deptarture Date	E1-E9 DOD	O1-O5 DOD	O6-O10 DOD
59	2003 M3ABR5R031	CHAPLAIN SERVICE SUPPORT APPRENTICE COURSE	03A	Maxwell AFB	10/6/2002	11/15/2002	30	0	0
ROB (3-level Tech Training)		Edit Lodging			Last changed: 2003-05-09				
56	2003 MAFSNCOA100	USAF SENIOR NCO ACADEMY	03A	Gunter Annex	10/7/2002	10/21/2002	363	0	0
		Edit Lodging	NON-US = 2 INT. STUDENTS, OTHER = 5 COAST GUARD		Last changed: 2003-08-11				
55	2003 MASBC001	AIR AND SPACE BASIC COURSE	03A	Maxwell AFB	10/14/2002	11/8/2002	0	644	0
Students should be lodged by flights within a class, if possible		Edit Lodging			Last changed: 2003-05-07				

NOTE: Actual EMS output is abridged and edited for clarity.

Figure 2.7 – Sample EMS Lodging-Request Inquiry

In addition to AU's many courses, EMS includes other base activities that bring TDY personnel to Maxwell, such as the Senior NCO Academy graduation, Reserve/Guard training weekends, and Junior Reserve Officers' Training Corps (JROTC) visits. While many of these activities have a lower priority for on-base quarters than AU courses have, on-base lodging is provided, and alternative off-base arrangements are made when on-base facilities are insufficient.

While they are an excellent data resource, EMS lodging requests are an inexact measure of overall demand, for two reasons. First, projected course attendance often does not equal actual attendance. Projections typically overestimate actual attendance

because courses fail to fill all authorized slots, with the result that some room reservations go unused. Lodging updates reservations when projected totals or schedules of courses are changed in EMS.[41] Also, the lodging scheduling committee meets monthly to discuss course changes and other projected lodging issues.[42] Since projections rarely exactly predict reality, the execution of the planned reservations introduces inefficiencies into the system. The second discrepancy between EMS and overall demand is that course demand accounts for approximately 90 percent of all lodging demands, leaving 10 percent unspecified. To account for overall lodging demand, it is necessary to specify the remaining 10 percent by comparing course demands to executed occupancy.

LTS's occupancy reports record the actual number of personnel housed by facility type, but occupancy does not exactly equal demand. To estimate total demand from these occupancy figures, priority-one occupants in each on-base facility type are added to contract quarters.[43] Contract quarters are included in total demand because they represent a lodging requirement for on-base facilities and their occupants would have been lodged on-base if appropriate quarters had been available. Only priority-one demand is included in total demand figures, since priority-two demands do not drive contract-quarters costs.[44] Priority-two demands are subtracted from the occupancy data. Total demand represents a simplified estimate of the total priority-one requirement for on-base lodging.

---

[41] Changes to the online lodging-request-inquiry database are highlighted in yellow to alert lodging of the change.

[42] The committee includes representatives from lodging, the registrar, AU staff, particularly plans and programs (XP), and the major schools/courses.

[43] Facility types DVO, DVE, VOQ, and VAQ are included. TLFs are excluded in this study because the focus is on TDY demand.

[44] Family members accompanying official TDY personnel and relatives or guests of a military member assigned to the installation are two examples of priority-two (space-available) demand categories. Space-available demand is not a lodging requirement that drives contract-quarters costs, and official Air Force policy is to plan capacity according to priority-one demand (AFI 34-246, paragraph 1.11). Space-available rooms are available only after mission requirements have been filled. Reservations may be made 24 hours in advance of arrival for a stay of up to three days if space is available. After the third day, a space-available stay is day-to-day.

Unfortunately, LTS reports do not keep individual occupant records. Without the ability to track individual demanders, it is impossible to make conclusions about an occupant's length of stay, course grouping, or priority for on-base facilities. These are all important considerations in determining whether an occupant is placed on-base or off-base. Also, while historic occupancy can be useful in projecting future demand, it should not be the only tool used, since year-to-year demands change, as shown in Table 2.3. Accurate forecasts require more than just a look at the past; they require a consideration of future-demand projections, such as the projected course schedules in EMS.

Neither dataset individually provides a complete picture of overall demand, but when combined, they yield a more detailed, albeit imperfect, representation. This analysis generates demand by combining these two databases, using as much information as is available to improve estimation. Course demands are projected according to the course listing and schedules in EMS; this retains information on individual demanders, including start date, course length, and weighting, that is critical in determining who is placed in off-base quarters. The remaining demand, i.e., residual demand, is essentially the number of priority-one demanders not specified within EMS. Residual demand can be computed by subtracting daily EMS course demands from LTS's daily priority-one and contract-quarters occupancy figures. While this does not produce an exact measure, since EMS projections do not equal reality, combining the residual demand estimates with EMS's course demand yields a suitable overall representation because the combination maintains the overall demand totals from LTS and the specificity of individual demanders in EMS. The methodology for modeling residual demand is discussed in more detail in Chapter 5.

2.4.2 On-Base and Off-Base Reservations

Ideally, the Air Force would like to place all TDY personnel in on-base quarters, for convenience and to obtain a lower per-room average cost. However, constructing and maintaining on-base quarters to satisfy 100 percent of the priority-one demand would be

prohibitively costly because of demand spikes and surges. To minimize cost, the Air Force utilizes some combination of on- and off-base quarters.[45] Beyond the macro policy decision of how many on-base facilities to procure, the Air Force also decides the micro policy of which demanders have on-base priority and which must go off-base. Not all demanders are equal in priority for on-base lodging.

There are many alternative reasons for one group having a higher on-base priority than another. At Maxwell, some courses argue that on-base quarters are "required" for course effectiveness. Team integrity and unit cohesion are critical for developmental courses such as officer accession, PME, and 3-level tech training courses that, optimally, are placed together near their classrooms.[46] To aid student research, JAG course instructors prefer building 680 because of the building's Internet connectivity and online access to the legal library. International students who attend the PCS courses at AWC and ACSC seek lodging for nearly an entire year, arguing that their placements should be in an on-base facility with additional amenities. All these reasons relate to a preference for on-base quarters and how lodging affects a course's mission. Other priority schemes could seek to minimize the use of contract quarters by placing larger and longer courses first, without regard to course preferences.

AU devised a course-weighting scheme to establish the order by which courses are placed in on-base lodging. Each course is assigned a weight by which it is ranked in EMS, an order that is then used by lodging to make reservations. By reserving rooms in order of course weighting, lower-priority courses are placed after higher-priority courses. Nonstudent TDY personnel make their reservations separately from the course reservation scheduling and thus fall outside of this formal weighting process. However, the reservation system does attempt to give priority to students over normal TDY, according to AETC Supplement 34-246 (1.6.4.1), by scheduling courses in advance of most TDY reservations. While students do not bump TDY reservations already in the

---

[45] Determining that combination depends on a variety of things. Chapter 3 discusses Air Force methodologies for making this calculation, and this dissertation suggests an alternative methodology aimed at minimizing overall lodging expenditures.

[46] Through part of FY03, COT (officer accession) was housed in on-base lodging. Now, COT and BOT are both housed in OTS campus dormitories, except when overflow requires lodging facilities.

system, TDY personnel typically make their reservations only a few days before they travel, while courses are scheduled a quarter in advance. This timing ensures that most courses are placed before individual TDY demands.

In the course-weighting scheme, the most heavily weighted factor is the type of training activity (PME, tech training, PCE, seminar, etc.). Other weighting factors include course participants' rank, course length, course size, and a special category adding 50 points for courses designated by the AU vice commander as "Required on Base." Figure 2.8 is the ranking form used to calculate course weights for FY03. The total weight factor is the sum of points from each weighting factor. This example shows the weighting (55) for ASBC or SOS, the total of 50 points for a PME course plus 5 points for course length.

MAXWELL / GUNTER ON-BASE BILLETING WEIGHT FACTOR			
Weight is computed by adding corresponding scores from Type, ROB, Rank, Length, and Size			
Example 1: 10 Day long PCE course with 20 Students; 25 (type) + 0 (rank) + 3 (length) + 4 (size) = 32			
Example 2: 3 day special event with 100 participants; 0 + 0 + 1 + 9 = 10			
Note: ROB value is awarded after petition to HQ AU/CFRS			
	YOUR WEIGHT FACTOR:		55
TYPE EVENT	**VALUE**	YOUR EVENT'S	
Officer Accession Training (OAT), International Officer School (IOS) PME	65	VALUE:	50
3-Level Technical Training (TT), approved PME courses	50		
5 / 7-Level Technical Training (TT), AU AETC-funded PCE	25		
AU Schools Other Educational Activities (OEA) - seminars, workshops, etc	10		
Special Events (SE)	0		
NOTE: CC Justification required, AU/CV approval for on base billeting			
REQUIRED / REQUESTED (ROB) ON BASE REASONS	**VALUE**	YOUR EVENT'S	
Special Events (SE) that are Required on Base (ROB)	50	VALUE:	0
NOTE: Category applies to Active Duty, Reserve and National Guard on Active Duty only			
RANK (OF MAJORITY OF PARTICIPANTS)	**VALUE**	YOUR EVENT'S	
General Officers (0-7thru 0-10), Senior Executive Services	50	VALUE:	0
Colonel (0-6), Civilian Equivalent (GS-15), Senior Enlisted (E-8, E-9)	10		
All Others	0		
LENGTH	**VALUE**	YOUR EVENT'S	
1 - 3 DAYS	1	VALUE:	5
4 - 5 DAYS	2		
6 - 13 DAYS	3		
14 - 21 DAYS (2 - 3 weeks)	4		
22 - 42 DAYS (4 - 6 weeks)	5		
43 - 64 DAYS (6 - 8 weeks)	6		
GREATER THAN 64 DAYS (8 weeks)	7		
SIZE (NUMBER OF PARTICIPANTS REQUIRING BILLETING)	**VALUE**	YOUR EVENT'S	
1 - 10	1	VALUE:	0
11 - 14	2		
15 - 19	3		
20 - 24	4		
25 - 34	5		
35 - 49	6		
50 - 74	7		
75 - 99	8		
100 - 149	9		
150 - 300	10		
GREATER THAN 300	0		

Figure 2.8 – AU Ranking Form for Course Weights

This weighting scheme highlights the fact that maximizing on-base occupancy is not the top priority in lodging placement. If maximizing occupancy were the primary concern, we would expect course size and course length to be the most heavily weighted factors. Understandably, many other priority factors are taken into account when deciding which courses should have priority for on-base lodging. The importance of the course's mission seems to be the most important factor, given the relatively high weight attributed to course type.

An alternative priority scheme could be developed to minimize the use of contract quarters by scheduling the largest and longest courses first, without regard to course importance. This is analogous to a problem of placing rocks and sand in a jar. The most efficient way would be to place the rocks first, largest to smallest, then the sand.[47] While AU's current weighting system largely follows such a scheme because of ASBC, SOS, and the NCO academies' high weighting and large class sizes, giving other long courses such as the SOS international officer school or the comptroller course higher priority could improve on-base efficiency. Any efficiency improvements would then have to be weighed by decisionmakers against the loss of prioritization for "important" courses in on-base facilities, as smaller, high-priority courses are preempted and sent off-base when large/long courses are placed first. Balancing these competing criteria requires tradeoffs between course desires, course priority, and the effect on lodging expenditures. One of the goals of this model is to better inform the tradeoff decision by making the lodging costs of such tradeoffs more transparent. This example will be analyzed in Chapter 7 to illustrate the costs associated with the current weighting scheme and to show whether efficiency gains can be achieved by altering that scheme.

2.5 SUMMARY

This chapter has provided general background on the Air Force lodging system: Air Force lodging facility types, primary consumers of government quarters, the distinction between priority-one and priority-two, and regulations governing the use of commercial lodging, including on- and off-base movement rules. It has presented a thorough discussion of supply and demand issues specific to Maxwell-Gunter AFB, including the definition of supply and demand as it is used in this dissertation, the composition of supply and demand, course information, seasonal patterns, recent trends, and data sources. A brief discussion on course weighting and the AU registrar's scheduling function provides some insight into how lodging manages on-base priority in

---

[47] In 1973, Johnson showed that a strategy that orders items from largest to smallest and then places them in the first place they fit is never suboptimal by more than 22 percent and that no efficient bin-

making course reservations. Chapter 3 investigates alternative methodologies for balancing the tradeoff between on- and off-base quarters, thereby determining an efficient capacity level for the lodging system described in this chapter and in other organizations within DoD.

---

packing algorithm can be guaranteed to do better than 22 percent (Weisstein, n.d.).

3. ALTERNATIVE APPROACHES FOR DETERMINING FACILITY LEVELS

Given the unpredictable and stochastic nature of lodging demand, it is clear that some use of contract quarters is appropriate. The issue is the optimal scale for on-base lodging and, hence, use of contract quarters. Operating and maintaining enough on-base lodging facilities to meet the largest demand spikes is inefficient, as some rooms would remain empty nearly the entire year, whereas maintaining space for the minimum daily demand throughout the year results in high occupancy but intolerable contract costs. An optimal facility policy will recognize that some level of (slack) capacity should be available to meet heightened demands on some days, although rooms will remain vacant on others. Investigating when the level of slack capacity moves from being efficient to being wasteful is a matter for careful tradeoff analysis, but acknowledging the need for some slack capacity is a necessary first step.

Determining an efficient amount of on-base capacity is a complex problem. The uncertainty of future requirements necessitates planning with imperfect demand forecasts. For simplicity in planning, forecasts are typically aggregated to represent the average daily lodging demands by month.[48] Using daily-demand averages for each month has serious limitations for accurately projecting on-base occupancy rates and contract quarters. Monthly averages eliminate daily variability and will overstate the effectiveness of on-base facilities for meeting demand. Day-to-day variability causes some courses to move off-base during surge periods, even if they fit on-base all other days.[49]

Further complicating the optimal-capacity determination is the seasonality of course scheduling, which results in overflowing demand in some periods and excess capacity in others. Since the chosen on-base facility capacity remains the same throughout the year, it is important to balance the off-season and on-season periods. The price of off-base hotels must also be considered, since as the cost differential between on- and off-base rooms gets smaller, it becomes relatively more efficient to maintain fewer

---

[48] Keesler Air Force Base Needs Assessment, p. K-1, and Army right-sizing model.

rooms and rely more heavily on commercial lodging. Furthermore, capacity is added in bulk thresholds, one facility at a time, often with 100 rooms or more per facility.

Consequently, a policy that looks purely at slack capacity derived from the on-base occupancy figures to judge whether future construction is justified ignores necessary complexity. An efficient facility policy should account for these complexities in determining the "right" number of on-base rooms. In practice, however, current determination methodologies are too simplistic. This chapter reviews current Air Force and Army methodologies, highlighting apparent deficiencies, and proposes a more complete tradeoff analysis, which is specified in the remainder of this dissertation.

3.1 JUSTIFYING CONSTRUCTION AT MAXWELL AFB

Justifying construction of Maxwell's new lodging facilities has been difficult, primarily because of low historical annual occupancy (Table 3.1), a fact that consistently argues against additional construction. However, focusing solely on this statistic belies the urgency of the need for additional facilities seen by Maxwell's leadership:

- Maxwell's highest construction priority for FY04 and FY05 POM was phase III of the SOC lodging plan.[50]
- Four of AU's top six MILCON priorities for FY05 were additional lodging facilities.[51]
- Enlisted dormitories at Maxwell have been converted into lodging facilities.
- Enlisted facilities were reclassified into officer facilities to meet higher officer requirements.
- When vacant, TLFs are used as visiting quarters to maximize on-base occupancy.
- Grossly substandard facilities continue to be used despite frequent student complaints.

---

[49] AETC Supplement 1 to AFI 34-246 allows for moves back on-base after five days.

[50] Phase III was the top priority for FY05 until the project was reinstated into the FY04 MILCON submittal in January 2003.

[51] Memorandum for HQ AETC/CE, undated.

Annual contract-quarters utilization increased from 57,000 in FY02 to over 69,000 in FY03. Until now, arguments for construction have centered on a collection of anecdotes: statistics for aggregate occupancy and contract quarters, a 1,000-room requirement when ASBC and SOS are in joint session, and the demolition of two lodging facilities to prepare a site for new construction. While each anecdote makes a compelling argument for or against additional construction, the problem is that there has been no comprehensive look at Maxwell's lodging operation to determine how many on-base rooms and consequent contract-quarters used would minimize total lodging cost to the Air Force. How should a decisionmaker evaluate all the pieces of anecdotal evidence to make a decision regarding aggregate facility capacity, particularly if pieces oppose each other? Table 3.1 illustrates an example of aggregate measures that tell opposing stories of whether or not additional construction is warranted.

Table 3.1
Historical Annual Occupancy and Contract Quarters at Maxwell and Gunter

	FY00	FY01	FY02	FY03
Occupancy, %	73.9	72.1	74.4	80.4
Contract quarters	61, 000	57, 000	57, 000	69, 000

The Air Force standard aims to satisfy 90 percent of priority-one demand in on-base facilities while achieving 85 percent occupancy. This standard is an informal target rather than an explicit regulation,[52] but it does provide a guideline for capacity determination because it is used by the needs assessments to evaluate capacity (Section 3.2). Essentially, the standard provides informal guidance on how to balance the tradeoff between on-base and off-base quarters. However, these two objectives can be in tension, and there is little guidance for trading off between the two. For example, ensuring that 90 percent of demand is met on-base could require additional facilities and could decrease annual-

[52] Mike Wilson, Air Force Services Agency

occupancy rates below the 85 percent target. Table 3.2 compares the percentage of overall priority-one demand lodged in on-base quarters with the resulting occupancy at Maxwell over the past four fiscal years. For the most part, on-base quarters have housed approximately 90 percent of demand, but on-base occupancy has dropped below the 85 percent target. Maxwell could have aimed for higher occupancy by limiting supply, thereby increasing occupancy but also shifting a higher fraction of demand off-base.[53]

Table 3.2
Historical Annual Occupancy and Share of Demand Met On-Base at Maxwell and Gunter

	FY00	FY01	FY02	FY03
Demand met on-base, %	86.2	90.0	90.0	88.5
Occupancy, %	73.9	72.1	74.4	80.4

As evidence of this tradeoff, the priority of constructing additional lodging facilities at Maxwell was downgraded despite high annual contract-quarters usage, because of the base's low annual-occupancy averages. In the budget debate for FY04, the SOC lodging plan's phase III was programmed to construct an additional 162 rooms. Despite being ranked as the top-priority project in AETC and seventh overall in the MILCON prioritization as late as September 2002, the project was removed from the appropriation request in October 2002. The AU Commander, Lieutenant General Lamontagne, fought for reinstatement by justifying the requirement and describing the negative ramifications of delaying construction.[54] The attempt at reinstatement appeared unsuccessful at that time, as the budget went forward without phase III. Surprisingly to base personnel, however, phase III was reinstated when the program budget decisions were announced to the services in January 2003 for incorporation in the FY04 President's budget.

[53] Maxwell could have restricted supply by not converting dormitories to lodging facilities.

Maxwell AFB had difficulty justifying additional facility construction with recent annual-occupancy averages below 80 percent. While many of the arguments to justify the requirement were persuasive,[55] the occupancy rate gave the appearance of slack capacity. This example shows that Maxwell should have a comprehensive needs assessment that balances the tradeoff between contract quarters and on-base vacancies to find the least-cost approach to meet lodging needs. In some cases, the 90 percent demand/85 percent occupancy standard is an overly simplistic management tool for determining the least-cost lodging level, especially at bases with seasonal and daily demand variability.

In the coming years, as AU attempts to justify the remaining phases of the SOC lodging plan (phases IV through VII), it will become incrementally more difficult to justify additional construction. The completion of the initial phases will likely reduce the use of contract quarters and further drive down occupancy rates. Nevertheless, there is a level of on-base capacity and consequent contract-quarters usage that would ensure the least-cost provision for meeting Maxwell's lodging requirements. A comprehensive needs assessment is required to establish a target capacity level by balancing the competing criteria of on-base vacancies and contract quarters. Knowing the efficient target capacity would greatly enhance the debate and would allow Air Force planners to evaluate competing construction criteria. In addition, an analysis would provide more accurate predictions of the implications of forestalling construction, better informing the debate when tradeoffs are made during MILCON prioritization.

3.2 AIR FORCE NEEDS ASSESSMENTS

When possible, the Air Force subcontracts a formal needs assessment process to analytically determine the desired number of lodging facilities. However, consistently

---

[54] Bullet background paper on SOC phase III MILCON, 22 October 02.

[55] Among other factors, the background paper cited the following: (1) the demolition of lodging facilities 1414 and 1415 removed 164 rooms, since these buildings occupied the site for phase III, (2) high-demand periods when both ASBC and SOC are in session require more than 1,000 rooms, (3) cancellation requires securing a total of $8.8 million for contract quarters across the FYDP (FY05–FY09), (4) decreases in slack capacity make it more difficult to perform maintenance without increasing off-base use, and (5) 50 percent of Maxwell's current rooms are substandard.

compiling these studies at all bases and incorporating yearly changes is an unrealistic goal. In recent years, Evans & Chastain, L.L.P., and PricewaterhouseCoopers have conducted the assessments for the Air Force Services Agency. Maxwell has not been evaluated, but Evans & Chastain's recent assessment at Keesler AFB illustrates the assessment process and can be applied to the issue at Maxwell.[56] The contract-quarters problem at Keesler is more severe than that at Maxwell—contract-quarters costs at Keesler totaled $13 million in FY02 and $16 million in FY03. In response, the Air Force proposed construction of additional facilities. The needs assessment was performed to evaluate the Air Force's proposal and justify the construction requirement.

This section evaluates the Keesler assessment's methodology for determining the optimal number of facilities to construct.[57] It is not a reevaluation of the recommendation. We believe that the assessment has two general methodological shortcomings. First, it uses daily-demand averages by month to project on-base occupancy statistics and contract quarters by differencing demand and average total supply. This dissertation labels that difference "excess demand." Second, the use of excess-demand measures to project contract quarters assumes too much efficiency in on-base facility placements and will understate the actual number of contract quarters. By definition, subtracting supply from demand to project contract quarters assumes that when daily demand is less than the number of rooms in inventory, there will be no contract quarters and all demands will be met on-base. Maxwell's daily occupancy data invalidate this assumption, since contract quarters also accrue on days when demand is less than supply. Consequently, the Keesler assessment's occupancy computations and projected contract quarters are based on overly optimistic efficiencies in utilizing on-base facilities and will result in an understatement of contract quarters.

As evidence, the Keesler needs assessment's methodology estimated annual contract-quarters costs to be $6.4 million at FY02 demand levels and the current facility

---

[56] Appendix B includes more information on the Keesler needs assessment, including screenshots from the draft report.

[57] Keesler needs assessment, pp. K-1 and K-2.

inventory (1,304 rooms).[58] In reality, contract quarters costs were $13 million in FY02 and nearly $16 million in FY03. Since the estimates were completed during FY03 using FY02 data, it seems plausible that they should have accounted for the higher-than-projected actual costs in FY02, a gap that grew in FY03 under a similar projected demand pattern. There may be other reasons for this understatement beyond those presented here, but since historic data from FY02 were used, demand or supply uncertainty is not one of them.

This dissertation concludes that the needs assessment's underestimates are the result of an overly simplified methodology that will always underestimate contract quarters. Sections 3.2.1 and 3.2.2 illustrate why this is the case. This calls into question the conclusions of the Keesler capacity analysis, because a tradeoff analysis that includes these higher contract-quarters estimates would likely recommend constructing additional facilities beyond the 1,458 rooms recommended by the study. Reviewing the construction recommendations is beyond the scope of this analysis, which is intended simply to evaluate the needs-assessment methodology. However, it is recommended that the Air Force revisit the conclusions of the Keesler needs assessment in light of the methodological discussion presented here.

To illustrate why differencing monthly demand and supply averages is insufficient, Subsections 3.2.1 and 3.2.2 apply the methodology from the needs assessment to Maxwell's daily lodging data from FY03.[59]

3.2.1 Using Daily-Demand Averages

Average monthly statistics conceal the day-to-day fluctuations within a month and result in consistent underestimates for contract quarters. Daily demand can fluctuate

---

[58] Keesler needs assessment, p. K-2. Appendix B replicates the calculation, using the presumed Keesler needs-assessment methodology.

[59] This analysis had access to daily data for only one fiscal year at Maxwell AFB; however, Maxwell data are sufficient to illustrate the methodological shortcomings, which are not specific to a particular base.

significantly across the month, with some days having very high demand due to high base activity or a high volume of ongoing classes, while other days, such as weekends, remain low. The downside of monthly averages is that aggregating these variations in a single demand statistic effectively eliminates daily variability and smooths demand spikes. Consequently, the demand averages sharply underestimate the number of days when demand will exceed on-base capacity.

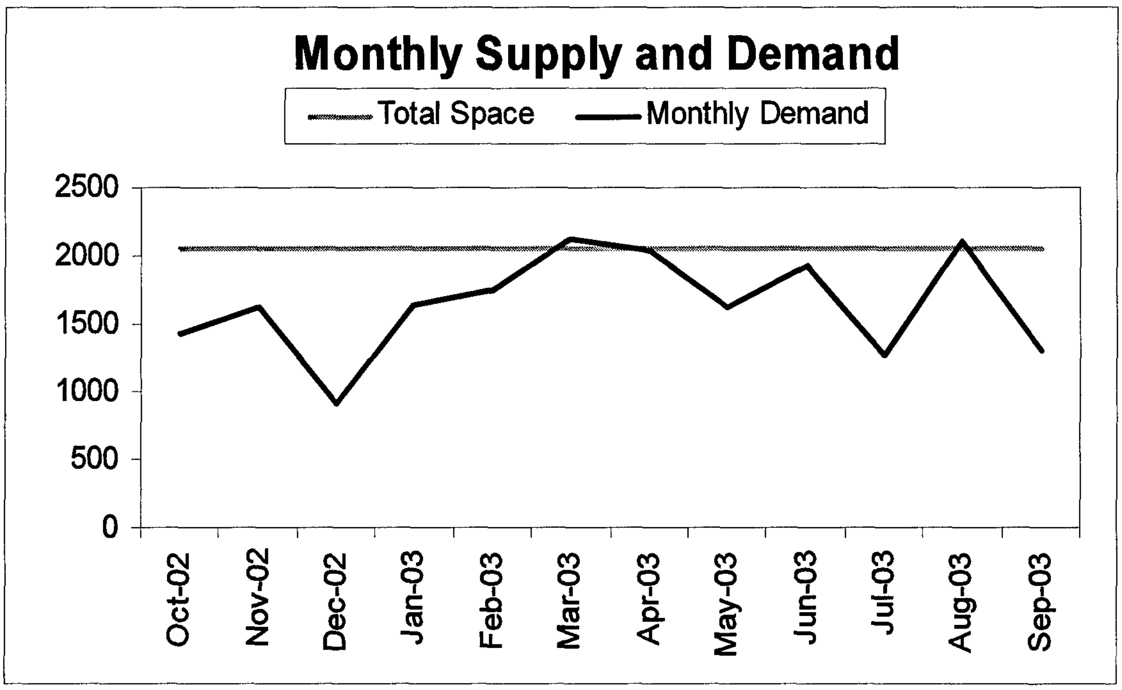


Figure 3.1 – FY03 Daily-Supply-and-Demand Averages by Month at Maxwell and Gunter

Figure 3.1 illustrates the daily-demand averages for each month and the total number of rooms on-base at Maxwell AFB for FY03. A planner might incorrectly suggest that Maxwell, with approximately 2,050 rooms on-base, could meet nearly all demands in on-base facilities; only March and August would require a small number of off-base facilities. However, monthly averages conceal the underlying variability that can be seen only in daily-demand data. Increased variability will intensify the daily spikes that exceed fixed capacity, requiring off-base lodging. Simultaneously, the decreased share of

demand in on-base lodging will result in lower occupancy rates. Figure 3.2 substitutes daily-supply-and-demand data for the monthly averages in Figure 3.1.

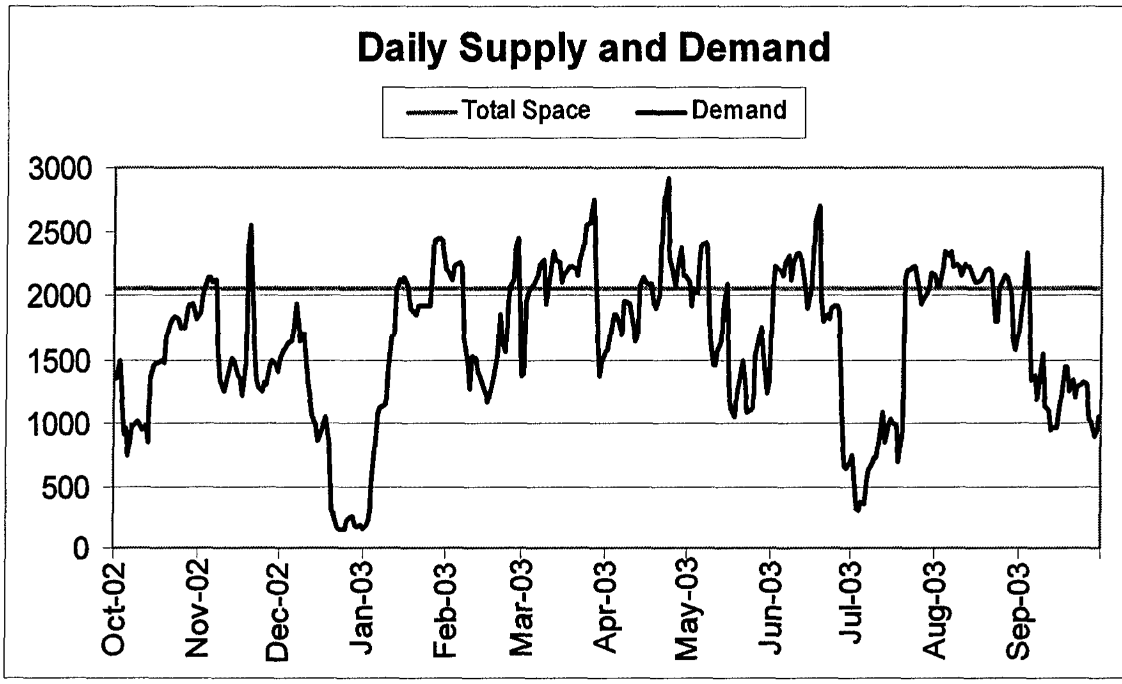


Figure 3.2 – FY03 Daily Supply and Demand at Maxwell and Gunter

Facility planning using average monthly demand will overstate the effectiveness of a given capacity level at meeting demand. This in turn underestimates the need for contract quarters, thereby resulting in a lower efficient capacity.

3.2.2 Differencing Supply and Demand Fails to Accurately Predict the Need for Contract Quarters

Although intuitive, a simple difference of daily demands and total facility space understates forecasts for daily contract quarters and overstates on-base occupancy. For example, Figure 3.2 shows only one daily-demand spike exceeding total supply in the month of September 2003. The demand spike occurred on September 3, when a demand of 2,325 rooms exceeded total supply by approximately 275 rooms. However, this understates September's actual contract-quarters total of 2,003 off-base rooms.

There are three explanations for this underestimate: blocked spaces that restrict supply, restrictive movement policies such that contract quarters persist, and lodging's micro policies that restrict some on-base facility placements. Table 3.3 compares actual contract quarters in FY03 with projections from the data in Figures 3.1, 3.2, and, later, 3.3. The excess-demand projections dramatically understate actual contract quarters even in the daily data.

Table 3.3
Comparison of Actual Contract Quarters with Excess-Demand Projections

	FY03
Contract-quarters projections from monthly average	
Demand – total space (Figure 3.1)	4,184
Contract-quarters projections from daily demand data	
Demand – total space (Figure 3.2)	22,446
Demand – available-space projections (Figure 3.3)	28,498
Actual contract quarters	~ 69, 000

Subtracting total space from demand yields incorrect estimates because total space neglects the effect of blocked spaces, which reduce the number of available bed spaces. As shown in Chapter 2, available space is a better supply metric than total space. Thus, Figure 3.3 compares daily demand with available space.

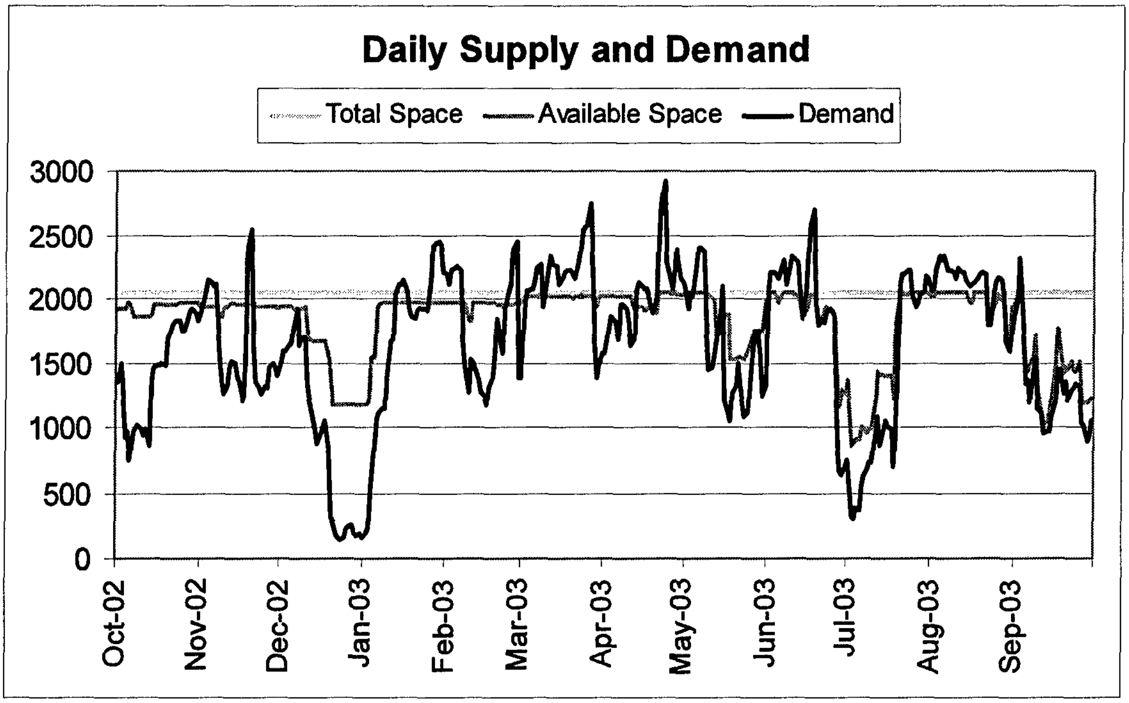


Figure 3.3 – FY03 Daily Total Space, Available Space, and Demand at Maxwell and Gunter

Once blocked spaces are included, the number of projected contract quarters needed to meet excess demand increases to 28,500. Still, this accounts for less than half of the actual contract quarters in FY03. This number is important because it represents the "unavoidable" annual contract quarters, given the current supply and demand.[60] Even if daily lodging placements filled all on-base rooms before utilizing off-base quarters, 28,500 contracted bed spaces were still projected to be needed to meet excess demand. Actual contract-quarters totals reveal that on-base facilities are not fully utilized before employing off-base quarters. Figure 3.4 compares actual contract quarters to excess-demand predictions for FY03.

---

[60] These contract quarters are not completely unavoidable, but resolving them would require supply or demand interventions such as constructing additional facilities, decreasing blocked spaces, or changing the composition of demand (i.e., smoothing course flows).

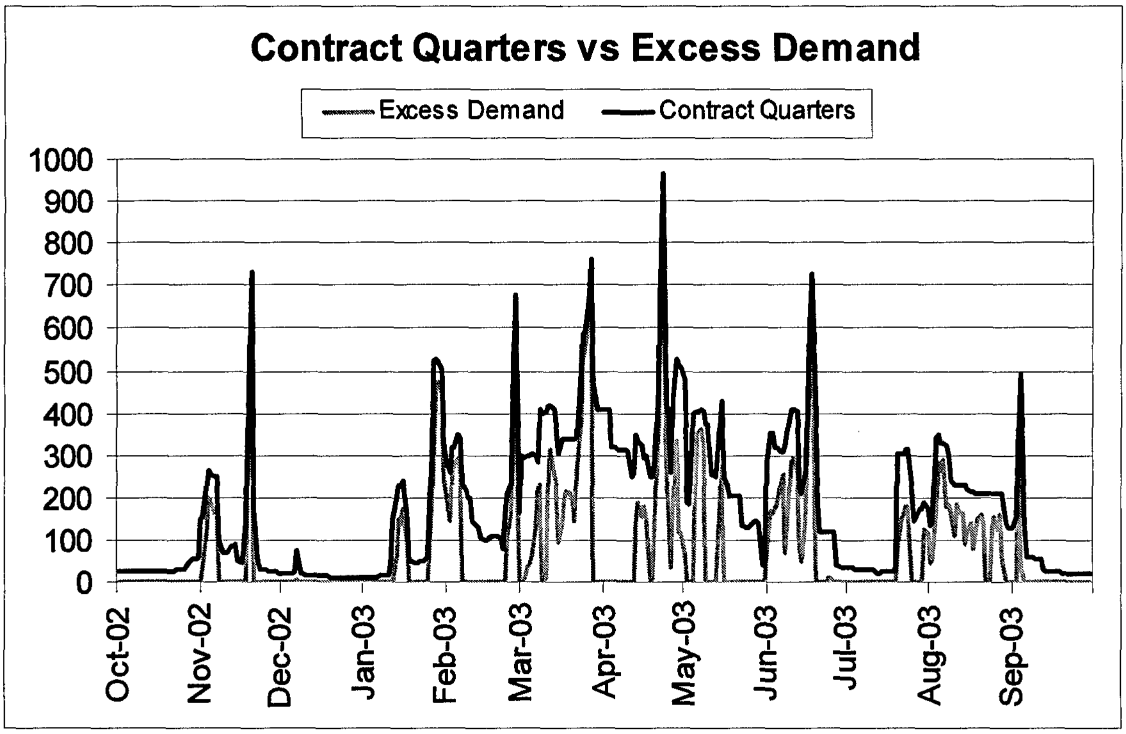


Figure 3.4 – FY03 Daily Contract Quarters and ExcessDemand (Total Demand Minus Available Supply) at Maxwell and Gunter

The two primary explanations for contract quarters accruing on days when demand does not exceed available space are restrictive movement policies and lodging's micro policies that restrict some on-base placements. Once personnel are placed off-base because of on-base unavailability, they tend to stay off-base. For convenience and morale purposes, the Air Force has recognized that it is not wise to continually redistribute personnel between on- and off-base quarters. Although mandating frequent moves would improve on-base occupancy and would eliminate long off-base stays, personnel inconvenience is an important consideration.

Before May 2002, Air Force personnel typically remained in their original lodging placement for the duration of their stay. This policy led to a large number of contract quarters that could have been saved through a movement policy that returned some personnel to base lodging when rooms became available. In May 2002, AETC issued the supplement to AFI 34-246 to improve on-base occupancy by enforcing the movement policy outlined in Section 2.1. These conditions are intended to limit inconvenience, while still achieving AETC's objective of improving on-base occupancy and limiting

contract-quarters expenditures. In FY03, reassigning personnel to on-base quarters saved the Air Force more than $500,000 in off-base-cost avoidance. Although they represent an improvement over previous years, the movement rule restrictions (only one move and a five-day stay in each location) continue to perpetuate some inefficiency, because contract quarters persist on days when on-base quarters are available. Striking the balance between cost savings and traveler convenience requires an understanding of how different movement policies affect lodging cost. Chapter 7 will illustrate how the simulation model can be used to evaluate the costs of different movement policies.

Restrictive movement rules cause contract quarters to persist on days other than those when a shortage actually occurred. This implies at least one on-base shortage at some point during a visitor's stay. However, these shortages are not always clear from the excess-demand data in Figure 3.4. The arrows in Figure 3.5 draw attention to examples of periods in which contract-quarters levels do not correspond to excess demand.

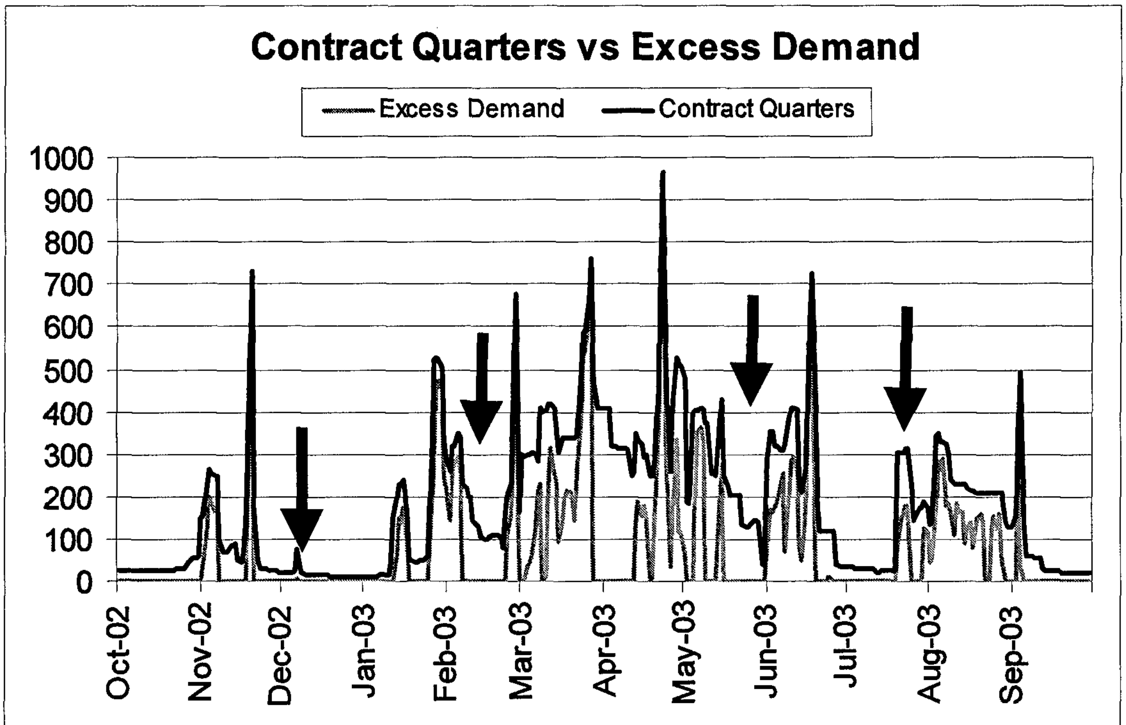
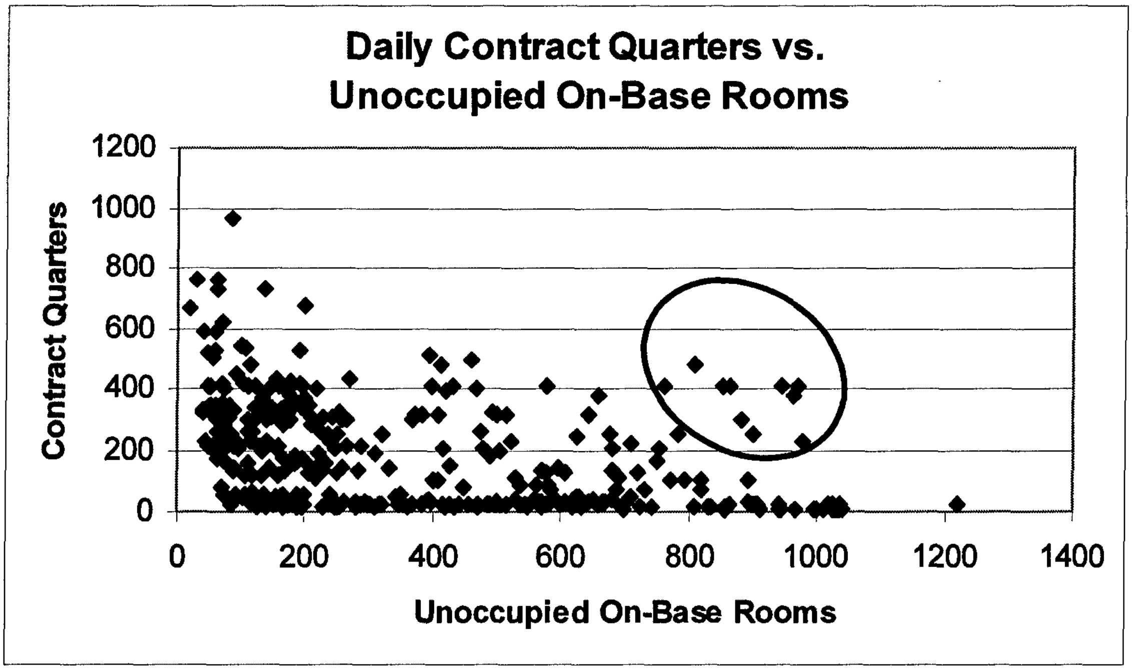


Figure 3.5 – FY03 Daily Contract Quarters and Excess Demand (Total Demand Minus Available Supply) at Maxwell and Gunter – Highlighting Periods When Contract Quarters Do Not Correspond to Excess Demand Levels

The arrows highlight periods in which either the spike in contract quarters is larger than the excess-demand spike or contract quarters persist beyond five days after the excess-demand spike. These examples and, more generally, the fact that daily contract quarters exceed excess-demand projections on all days reveal that contract quarters can occur without demand exceeding available on-base supply. Restrictive movement policies cannot fully explain the difference between contract quarters and excess-demand projections. This implies other on-base placement restrictions leading to nonoptimal utilization, since on-base occupancy is lower than "available rooms" would predict.



NOTE: Oval highlights data points discussed on page 53.

Figure 3.6 – Comparison of Daily Contract-Quarters Bed Spaces with Unoccupied On-Base Rooms at Maxwell and Gunter

Figure 3.6 confirms that a significant number of rooms are unoccupied nearly every day, including days with high contract-quarters usage. On the majority of days with more than 200 contract quarters, 100 to 200 rooms are left unoccupied on-base. This suggests an efficiency threshold beyond which it is difficult to improve on-base occupancy and additional demands are met mostly by off-base quarters. This could occur for a variety of reasons: inefficient facility mix (VOQ, VAQ, DVO, etc.), keeping groups together for course integrity, gender or rank distinctions forbidding close-proximity placements,[61] unavailability of the same room for an entire length of stay, loss of reserved rooms due to no-shows, etc. The fact that contract quarters occur even on days when demand is less than available space has implications for using excess demand to

[61] Men and women cannot occupy rooms that share a bathroom. Additionally, colonels are rarely placed in shared-bath rooms; when the placement is necessary, the adjoining room is typically left unoccupied.

predict the number of contract quarters. Since excess demand is calculated by subtracting supply from demand, thereby assuming 100 percent on-base occupancy before contract quarters are utilized, excess-demand projections will understate the actual number of contract quarters.

Figure 3.6 also illustrates the earlier argument about restrictive movement policies incurring contract quarters on days with on-base vacancies. The oval in Figure 3.6 highlights a set of 11 data points that paradoxically represent a large number of contract quarters and on-base vacancies. In all cases, these occurred either immediately before or immediately after a large course or group of courses was in session. Despite the large course not being in session on these particular days, off-base occupants were not immediately drawn back to base, because of the movement rules. The number of contract quarters on these days is consistent with the number on adjacent days, when the larger courses were in session. Table 3.4 delineates each case.

Table 3.4
Days with High Contract Quarters and High On-Base Vacancies

Date	On-Base Vacancies	Contract Quarters	Explanation
3/1	881	300	ASBC (601) and paralegal course (82) begins 3/2
3/28	808	475	ASBC (601) ends 3/28 and SOS (390) ends 3/29
3/29	970	409	ASBC (601) ends 3/28 and SOS (390) ends 3/29
3/30	946	409	ASBC (601) ends 3/28 and SOS (390) ends 3/29
3/31	865	408	ASBC (601) ends 3/28 and SOS (390) ends 3/29
4/1	851	408	ASBC (601) ends 3/28 and SOS (390) ends 3/29
4/2	761	408	ASBC (601) ends 3/28 and SOS (390) ends 3/29
5/10	962	375	SOS (358) ends 5/9 and ASBC (581) ends 5/10
5/11	782	252	SOS (358) ends 5/9 and ASBC (581) ends 5/10
5/16	899	251	NCO Academy ends 5/16 and Operational Law (140) ends 5/17
5/17	977	225	NCO Academy (190) ends 5/16 and Operational Law (140) ends 5/17

NOTES: The numbers in parentheses are student totals for each course. Students typically depart on the day of course completion, so the last night in lodging is typically the night before the course end date.

In summary, suboptimal utilization, coupled with contract quarters persisting after excess demand has diminished, results in excess-demand projections considerably underestimating the actual number of contract quarters, even at the daily level. In our case study at Maxwell, the actual contract-quarters usage was more than twice the daily excess demand predicted for FY03 and more than 15 times greater than the monthly average projections from Section 3.2.1. The effect of blocked spaces, movement

restrictions, and lodging's micro policies that restrict on-base facility placements increases the reliance on contract quarters rather than oversimplified planning measures. Projections that assume away these factors will understate contract-quarters dependency and consequently will underestimate the lowest-cost capacity level.[62]

3.2.3 Shortcomings of the Current Air Force Approach

As shown in Sections 3.2.1 and 3.2.2, current methodologies utilized in Air Force needs assessments to project the numbers and costs of contract quarters may be oversimplified and insufficient to capture the realities of the lodging operation. The understatement of contract quarters will result in faulty tradeoff analysis when comparing the costs of contract quarters with the costs of on-base vacancies at varying facility levels. This will drive recommendations for a lower-than-efficient level of on-base capacity and will leave Air Force decisionmakers perplexed with higher-than-predicted contract-quarters costs.

Until recently, the analytic complexity of planning models has been necessarily limited because of data unavailability. Even though LTS records occupancy data at the daily level, it could not generate output in an analytically useful format. LTS reports were available in hardcopy format and had to be manually entered into Excel spreadsheets; there was no automated method for transferring data. Consequently, the daily data were typically aggregated into monthly occupancy statistics for the purpose of reporting these statistics to headquarters.[63] Deeper analytic scrutiny, particularly of daily data, would have required a much greater commitment of analytic resources to convert daily data from LTS into a different format. However, the Air Force is in the process of

---

[62] These distinctions will motivate the nonstandard treatment of shortages in the inventory model. In the standard inventory model, shortages occur only in time periods when demand exceeds supply (inventory). Given the discussed complexities in Maxwell's lodging system, shortages (contract quarters) occur even on days when demand does not exceed supply. Consequently, the model will have to better account for these shortages through simulation of the rules in the actual reservation and placement system.

[63] AETC Services collects annual occupancy reports from each base within the command. The reports contain monthly aggregated statistics for occupancy by facility type (VOQ, VAQ, etc.), space-available bed spaces, and contract-quarters bed spaces.

upgrading LTS to allow data output into Excel, which could allow easier data manipulation and greater analytic detail in future facility planning.

Planning typically requires simplifying a complex system to make analysis tractable; however, it is always important to note the simplifying assumptions and the possible resulting bias to conclusions. If simplifications combine to distort conclusions markedly, they must be accounted for qualitatively by shifting policy decisions in the direction of the bias, or quantitatively through a more rigorous approach. The Keesler needs assessment does not discuss or appear to account for any of the resulting bias in the capacity-tradeoff analysis, despite its underestimate of contract-quarters costs by several million dollars.

Since these needs assessments are used to establish the Air Force's least-cost capacity targets for on-base lodging, the Air Force must ensure that the methodology does not systematically understate the inherent realities and policies of the lodging system. If it does, the Air Force will consistently establish capacity targets below the efficient (least-cost) level. The evaluation of one case study suggests that this shortcoming may be systemic, resulting from an oversimplified methodology.[64] To validate this critique, estimates for contract-quarters utilization using excess-demand methodologies should be compared with the actual executed statistics at other bases. The evaluation would be similar to the approach taken here but could look across many bases and multiple assessments to reveal systematic trends.[65] Keeping in mind that demand and supply projections are uncertain, assessing the difference between projections and reality would be a move toward improved oversight and would evaluate the effectiveness of the current methodological approach. If the current methodology is found to be overly simplistic, a more rigorous analytic approach, overcoming many of these current

---

[64] This methodological critique was illustrated with only one base's data. However, the arguments presented in Sections 3.2.1 and 3.2.2 are applicable to any base with the discussed characteristics: daily variability, blocked spaces, daily movement restrictions, and micro policies that restrict some on-base facility placements.

[65] This analysis had access to daily data for only one fiscal year at Maxwell AFB. An analysis of multiple bases was beyond the scope of the study. However, with the new capability to export LTS occupancy data into Excel, a multibase analysis would be straightforward and well worth the effort to evaluate the current methodology for projecting contract quarters.

limitations, should be employed to determine an optimal capacity level. The remaining chapters of this dissertation illustrate one such approach.

3.3 ARMY RIGHT-SIZE MODELING

Right-sizing an installation's lodging operation is not a uniquely Air Force problem. Over the past three years, the Army has been developing an Excel-based right-sizing model to determine optimal numbers of lodging rooms.[66] Like the Air Force needs assessments, the Army model utilizes monthly demand averages to project off-base utilization and on-base occupancy. The model generates historical demand averages, using lodging data from the previous five fiscal years. These monthly demand averages are then differenced with monthly supply averages to predict off-base requirements and on-base utilization at the chosen supply level. This is similar to the monthly excess-demand projections described for the Air Force needs assessments. Consequently, the methodological issues discussed in Sections 3.2.1 and 3.2.2 apply to the Army's model as well.

Interestingly, the Army's model allows a variety of objectives for selecting the on-base capacity level: balancing off-base and excess on-base expenditures (their recommended approach, shown in Figure 3.7), accommodating 100 percent of demand on-base, setting capacity equal to average annual demand, evaluating current inventory, etc. Analyzing different objectives allows the decisionmaker to select a capacity level according to his or her desired occupancy and off-base utilization. Figure 3.7 is a screenshot of the Army's right-sizing model.

---

[66] Army Community and Family Support Center (USACFSC) and U.S. Army Forces Command (FORSCOM).

		Oct	Nov	Aug	Sep	Averages	
Avg Demand bed nights		13,980	9,627	14,727	13,894	12,477	
Cost Avoidance & Maint Cost balance	Of Avg Sold						
recommended at	111.878%	13,958	13,958	13,958	13,958	13,958	
Bed nights missing/excess		(22)	4,331	(769)	64	17,783	
Potential Gov cost avoidance		$827	FALSE	$29,265	FALSE	$141,422	
Lodging Cost to maintain		FALSE	($28,491)	FALSE	($422)	($141,422)	$0
Occupancy at recommended rooms							
number of bed nights available		13,958	13,958	13,958	13,958	13,958	
Actual Requirement		13,980	9,627	14,727	13,894	12,477	
CNA issued		22	(4,331)	769	(64)	(17,783)	
Occupancy %	89.38%	100.16%	68.97%	105.51%	99.54%	89.38%	

NOTE: Model image has been modified and months have been removed to fit on this page.

Figure 3.7 – Screenshot of Army Right-Sizing Model

The first row shows the total monthly demand used in the model, averaged from the previous five fiscal years. The next five rows compute the efficient crossover point between on-base and off-base expenditures. In execution, the model changes the recommended monthly supply (13,958) until the total annual government cost avoidance (contract quarters) is equal to total lodging cost to maintain (excess capacity). The efficient capacity is found when these two costs equalize (highlighted with an arrow in Figure 3.7). The problem with this methodology, as with the needs assessment, is that contract quarters and excess capacity are calculated through a simple differencing of monthly demand and supply, resulting in the issues discussed in Sections 3.2.1 and 3.2.2. The bottom rows in Figure 3.6 compute monthly occupancy statistics by dividing monthly demand by the chosen capacity level.

The Army admits that its model simplifies reality in order to make the analysis tractable. Collecting daily-demand data and creating a more complex model would have required time and resources that were unavailable. Automated data collection could allow analysis of daily-demand data, which currently must be extracted manually from lodging-occupancy systems. An effort is under way utilizing this model to right-size lodging operations throughout the Army. Capacity decisions must qualitatively account for the systematic bias of a simplified model or else risk underestimating the "true" efficient capacity level.

3.4 ALTERNATIVE METHODOLOGY

The objective of the methodology in this dissertation is the same as that of the methodoligies currently employed: to determine the capacity that minimizes total lodging cost. However, this dissertation uses more-detailed data and a more-rigorous approach to better estimate the number of contract quarters. This approach more closely represents the actual tradeoff between off-base and on-base costs. Through balancing this tradeoff, an efficient level of lodging capacity can be estimated that provides the least-cost overall solution. The problem is comparable to the broad economic and business literature on inventory theory, described in Chapter 4. This literature presents many models for analyzing these types of problems. The benefit of inventory models over a metric such as average on-base occupancy is that they take into account several important factors highlighted earlier in this section: seasonality of demand, daily demand variability, and the on-base/off-base cost ratio.

3.5 SUMMARY

This chapter has reviewed alternative methodologies for determining the most efficient number of on-base facilities. In the absence of a comprehensive needs assessment, justifying construction of additional lodging facilities at Maxwell has rested on persuasive anecdotal arguments. This justification has been difficult due to low average annual occupancy, i.e., below the Air Force's 85 percent target. Determining the efficient capacity level that minimizes total Air Force lodging costs would substantially alleviate future budget battles in justifying construction where such construction is needed. In many cases, the Air Force contracts independent needs assessments, like the Keesler needs assessment, to evaluate lodging-construction proposals. However, the methodology for determining least-cost capacity levels may be oversimplified and may understate the executed number of contract quarters. The two primary reasons for the understatement are (1) the use of monthly demand averages that conceal daily-demand spikes and (2) the fact that excess-demand calculations are a bad predictor of actual contract quarters because of blocked spaces, movement restrictions, and inefficient on-base placements. The Army developed a similar model, which suffers from the same

methodological problems. The remaining chapters of this dissertation propose an alternative methodology, rooted in the inventory literature, for evaluating the tradeoff in determining an efficient facility capacity.

4. REVIEW OF INVENTORY-THEORY LITERATURE

An optimal inventory level would balance the cost of holding additional on-base facilities against the shortage costs of not holding enough. Stripped of its complexity, this problem is similar to the classic newsvendor inventory problem, where there is a given demand distribution as well as costs for purchasing, holding, and being short of inventory.[67] Section 4.1 investigates current and historical treatments of the inventory problem, and Section 4.2 applies the literature to the Maxwell lodging problem.

4.1 INVENTORY LITERATURE

There are hundreds, if not thousands, of articles in the inventory-theory literature and many books devoted to the topic.[68] It would be impossible to review the entire literature, including the many substantive areas that have themselves created branches within it, such as computing optimal (s, S) policies,[69,70] efficient computing methods for solving optimal-inventory problems,[71] optimal policies in dynamic inventory models,[72] solving inventory problems when underlying demand distributions are unknown,[73] capacity expansion,[74] differing treatment of ordering lead times,[75] perishable

---

[67] Arrow, Karlin, and Scarf, 1958.

[68] Veinott, 1966, p. 746; Axsater, 2000; Silver, Pyke, and Peterson, 1998.

[69] Initial work in Arrow, Harris, and Marschak, 1951, with follow-on work by others, including Iglehart, 1963; Veinott and Wagner, 1965; Veinott, 1966.

[70] (s,S) policies are a class of ordering solutions within inventory theory, so named because of the ordering policy. (s, S) ordering policies create an inventory band such that the manager orders once the inventory drops below s and orders to a fixed inventory level S. This type has been shown to be optimal for most inventory problems, as stated in Axsater, 2000.

[71] Veinott and Wagner, 1965; Federgruen and Zipkin, 1984.

[72] Summary and literature review in Veinott, 1966.

[73] Pioneering work by Scarf, 1959.

[74] Dynamic optimal-capacity expansion with uncertain demand in Manne, 1961; survey in Luss, 1982; more-recent work on capacity expansion in the services industry by Gaimon, 1994, and Berman, Ganz and Wagner, 1994.

[75] Arrow, Karlin, Scarf, 1958, p. 24; optional/emergency time lags are addressed in Neuts, 1964, and Daniel, 1963.

inventories,[76] and continuous-demand distributions.[77] This section provides an overview of the general concepts common throughout the inventory literature and then focuses on those directly applicable to the lodging analysis.

Typically, production and inventory models determine when to produce goods for sale in current and future periods. Goods that are sold in future periods are often produced in advance to achieve cost savings (economy-of-scale production, avoiding increasing costs over time, etc.) or to avoid delays in getting to market. As a result, they must be held in inventory, accumulating the associated holding costs until they are ready for sale. The choice between producing goods when they need to be sold and producing them earlier and holding them in inventory depends upon their relative profitability. A great deal of the literature deals with the multiperiod production and inventory decisions that firms face.

The standard inventory models determine an optimal (or at least "best") level of inventory to hold, based on a given demand distribution. The most notable reference in this literature is *Studies in the Mathematical Theory of Inventory and Production*, by Arrow, Karlin, and Scarf (1958), which summarizes the early literature and still provides a comprehensive overview of inventory problems.[78] The introductory chapter, "The Nature and Structure of Inventory Problems," states that each problem has many common components with differing treatments in each model: demand, costs, ordering, time step, and analytic approach. Each of these components is discussed in the following subsections. Much of the development of the inventory literature over time can be described as flexible enhancements to components of the original model: one-period to multiperiod (dynamic) models, single- to multiple-product inventories, single to multiechelon distribution, inclusion of ordering lead times (deterministic, then stochastic), perishable inventories/decay of inventories, discrete to continuous demands,

---

[76] Survey by Nahmias, 1982; tracking perishable items through lifetime by Fries, 1975; lead times added by Williams and Patuwo, 1999.

[77] Browne and Zipkin, 1991; Johansen and Thortenson, 1996, 1998; Johansen and Hill, 2000.

[78] This book is still cited in today's research (see Johansen and Thorstenson, 1996, Williams and Patuwo, 1999).

etc. The components of inventory models and the general methodological framework have not changed, and they provide the organization for this discussion.

4.1.1 Classifying Demand

There are two major classes of inventory models: deterministic, where future demand flows are known, and stochastic, where demands are based on a distribution. Deterministic models are relatively uninteresting and are easily solved even in systems with ordering lags.[79] Most of the literature focuses on stochastic demand models, with both known and unknown distributions, since they more accurately represent the complexity of real-world problems. Forecasting uncertain future demand flows is critical to determining policies for dynamic inventory models. Both the level of demand and the uncertainty of the forecast affect inventory policies. The more uncertain the forecast is, the larger the optimal on-hand inventory must be to guard against that uncertainty.[80]

In most models, stochastic demands are represented by discrete pulls from the stochastic distribution in each time step (discrete time-step models are discussed in Section 4.1.4). However, more-recent models[81] have explored continuous-demand distributions, such as the Poisson distribution.[82]

4.1.2 Accumulating Costs

A full accounting of all associated revenues and costs is necessary to evaluate the overall effect of different inventory policies on a firm's objective—typically, maximizing profit or minimizing cost. Inventory models account for all costs associated with production, storage, and bringing the product to market. In most cases, these costs include

---

[79] Arrow, Harris, Marschak, 1951, p. 255; for solving dynamic lot-sizing problems, see Axsater, 2000.

[80] Axsater, 2000, p. 5.

[81] Browne and Zipkin, 1991; Johansen and Hill, 2000.

[82] Johansen and Thorstenson, 1996, 1998.

- **Ordering/production costs.** Ordering and production costs are those associated with the firm producing or ordering the product. "In stocking a commodity, there will be a cost $c(z)$ to ordering or producing a given amount z of the commodity."[83]
- **Holding costs.** Holding costs are those associated with maintaining the stock of inventories on hand until they are sold. They include all costs that are variable with inventory level. They may include the opportunity cost of capital, handling cost and maintenance, storage costs, insurance, damage, perishable-inventory decay, and/or obsolescence.[84]
- **Penalty (shortage) costs.** Penalty costs accumulate when demand cannot be met with the on-hand supply. It is often too costly to guarantee that demand will be met in all circumstances, especially when future demands are uncertain.[85] These costs are difficult to measure but typically represent lost sales, loss of consumer good will, discounts for backlogged orders, and/or administrative costs.[86]

4.1.3 Ordering

Ordering or producing[87] additional inventory is a critical component of the inventory-control process. The responsiveness of the inventory reordering system determines, in large part, the optimal inventory level. In the ideal ordering system with no time lags and no additional costs for instantaneous delivery, shortage and holding costs would be eliminated, because the optimal inventory policy would order after demand is realized.[88] Lead times affect the inventory policy by increasing the period over which demands are met through current inventory or previously placed orders. The treatment of ordering lags differs by model, but there are generally three possibilities:

---

[83] Arrow, Karlin, Scarf, 1958, p. 19; Axsater, 2000, p. 26; Hillier and Lieberman, 2001, p. 938.
[84] Axsater, 2000, pp. 25-26; Hillier and Lieberman, 2001, p. 939.
[85] Arrow, Karlin, Scarf, 1958, p. 21.
[86] Axsater, 2000, p. 26; Hillier and Lieberman, 2001, p. 939.
[87] If the retailer controls production, adding inventory is a production, not an ordering, decision.

fixed lag between ordering and delivery, random lag based on a known distribution, or a multitier ordering system in which a premium can be paid for priority or emergency shipments.[89]

In the deterministic-demand case, fixed-ordering time lags are of no consequence because an optimal ordering policy would simply order correspondingly earlier.[90] Stochastic-demand and stochastic-ordering lags complicate the ordering problem because ordering takes place before demands are realized and demands are met from inventory. Optimal ordering policies take the form of (s, S) or (R, Q).[91] (s, S) ordering policies create an inventory band such that the manager orders when the inventory drops below s and orders to a fixed inventory level, S. Conversely, (R, Q) models order when inventory drops below the inventory level, R, but order a fixed quantity, Q.

4.1.4 Analyzed Time Step

Time is an important dimension in inventory models, since the way the system changes over time affects the optimal policy. Demand and some costs are functions of time and are best expressed as rates. Generally, inventory models are analyzed (reviewed) in discrete time steps rather than in continuous time.[92] Discrete-time review often represents the reality of the system where firms manage their inventories on a weekly or monthly basis and place aggregated orders because of the fixed costs of order placement.[93] Some recent models[94] have explored continuous-stochastic-demand distributions such as the Poisson distribution.[95]

---

[88] Axsater, 2000, p. 68.

[89] Arrow, Karlin, and Scarf, 1958, p. 24; Daniel, 1963; Fukuda, 1964; Neuts, 1964.

[90] Arrow, Harris, and Marschak, 1951, p. 255; Axsater, 2000, p. 30.

[91] (s, S) optimality is discussed in footnote 70. In a continuous-review model, (R, Q) is equivalent to (s, S) and is therefore optimal (Axsater, 2000, p. 82).

[92] Arrow, Karlin, and Scarf, 1958, p. 24. Examples are given in Angelus and Porteus, 2000; Berman, Ganz, and Wagner, 1994; Luss, 1982; Neebe and Rao, 1983.

[93] Scarf, 1960, chap. 13; Zabel, 1962, p. 123; Veinott, 1966, pp. 1070–1071.

[94] Browne and Zipkin, 1991; Johansen and Hill, 2000.

[95] Johansen and Thortenson, 1996, 1998.

Discrete models adequately represent continuous processes and the reality of inventory management when the time step is sufficiently small that no event can occur other than at the chosen time.[96] The use of discrete models in which demands, orders, and deliveries take place at one time in a succession of equally spaced time steps is a common simplification in the literature. Time steps also facilitate the discrete nature of independent pulls from the demand distribution, once per time period.[97] The theoretical literature refers to these discrete time periods in nonspecified lengths of time, such as periods t = 1, 2, ...T. In the applied literature, the time steps are monthly or longer, which appears to be a suitable level of aggregation for most models.[98]

4.1.5 Analytic Approach

There are two main branches of analysis within the inventory literature: optimization and simulation. Optimization and computing optimal policies are the subjects of the majority of the articles reviewed in the literature. Optimization typically involves finding a procedure that will optimize a defined objective function. These functions rely on simplifying assumptions that distort reality for the sake of setting up equations and solving the model. The solution typically results in decision rules for ordering or producing, such as the two most popular ordering policies (s, S) and (R, Q).[99] Optimization equations have been used to solve for optimal inventory-holding levels.[100] For completeness, the generic derivation for the optimal inventory policy is given below.

Step-by-Step Derivation of the Optimal Policy[101]

- Set up a cost function that expresses holding (c_1), shortage (c_2), production costs (c), the distribution of demand ($\varphi_D(\xi)$), and the chosen inventory (y):

[96] Hillier and Lieberman, 2001, p. 941; Lian and Liu, 1999.
[97] Arrow, Karlin, and Scarf, 1958, p. 24.
[98] Angelus and Porteus, October 2000; Angelus, Porteus, and Wood, 2000.
[99] Arrow, Karlin, and Scarf, 1958, pp. 30–34; Scarf, 1960, pp. 196–202; Axsater, 2000, p. 28.
[100] Lau and Lau, 1996, p. 30; Hillier and Lieberman, 2001, pp. 969–971.
[101] Hillier and Lieberman, 2001, pp. 969–971.

$$G(y) = c_1 \int_0^y (y-\xi)\varphi_D(\xi)\, d\xi + c_2 \int_y^\infty (\xi - y)\, \varphi_D(\xi)\, d\xi \ + cy$$

- Minimize G(y) by taking the derivative and setting equal to zero:[102]

$$\frac{dG(y)}{dy} = c_1 \int_0^y \varphi_D(\xi)\, d\xi - \ c_2 \int_y^\infty \varphi_D(\xi)\, d\xi \ + c = 0$$

- This expression implies that

$$c_1\Phi(y^o) - c_2[1-\Phi(y^o)] + c = 0 \qquad \text{because} \qquad \int_0^\infty \varphi_D(\xi)\, d\xi = 1$$

- Solving this expression yields the optimality condition:

$$\Phi(y^o) = \frac{c_2 - c}{c_2 + c_1}$$

In lay terms, this condition says the optimal inventory quantity (y^o) occurs when the cumulative density function (CDF) equals the cost ratio:

$$\frac{\textit{Difference between shortage and production costs}}{\textit{Sum of shortage and holding costs}}.$$

In discrete-time-stepped models in the literature, shortages occur when the demand in a period exceeds the on-hand inventory. This is clear from the shortage-cost equation,

$c_2 \int_y^\infty (\xi - y)\, \varphi_D(\xi)\, d\xi$, which accumulates costs only when demand is greater than y. The literature does not discretely model the occurrence of shortages in a more complex manner.

Simulation solves the opposite problem to optimization by establishing feasible inventory policies and then asking what the effects of those policies will be on the firm's objective and finding the "best" solution among the analyzed policy alternatives. If a model can be created to represent the process, simulation offers a valuable tool for

---

102 Second-order conditions confirm the point as a minimum for all y:

$$\frac{d^2G(y)}{dy^2} = (c_1 + c_2)\, \varphi_D(y) \geq 0.$$

evaluating a finite set of policies.[103] In the words of Arrow (1958), "Each possible policy is then tested in the computer's simulation of the model, and the appropriate policy is selected according to the objective function... however, if the number of reasonable strategies is at all large, the machine time of simulation is apt to be prohibitively costly, if indeed it is at all possible."[104]

Further, simulation allows evaluation of different ("what if") inventory policies without direct implementation in the real world, where experimentation can be costly. Simulation approaches require constructing a model that closely reflects reality, with little reliance on simplifying assumptions that distort reality.[105] As an added benefit, simulation decision rules can incorporate the special conditions applicable to a particular firm's inventory problem, which cannot be represented in optimization equations.[106] Simulation offers a strong alternative methodology when the construction of optimality equations is difficult or unrealistic and the number of adoptable policies is finite.

4.2 APPLYING THE LITERATURE TO AIR FORCE LODGING

While the overlap with the general concepts from the literature should be clear, there are distinct differences in the Air Force problem and in this dissertation's approach. This section discusses how we apply each component of the inventory model to the Air Force lodging problem. The subsections follow the same ordering as those in Section 4.1.

Unlike typical consumable goods, lodging facilities are long-term assets in which the inventory—rooms available for rent—cannot be saved for future periods, yet it renews itself on a daily basis. Consequently, this model reflects the attributes of a one-period fixed-lifetime perishable-product inventory model, with the unusual addition that the inventory is fixed between periods in the short run. Typically, a perishable-product model is used to optimize inventories such as newspapers, flowers, fresh fruit, blood

---

[103] Arrow, Karlin, and Scarf, 1958, p. 35.
[104] Ibid., p. 17.
[105] Axsater, 2000, p. 182.
[106] Nam and Logendran, 1992, p. 268.

supplies, or seasonal clothing, which cannot be carried over to meet demand in future periods; therefore, it a useful framework for the Air Force's lodging-inventory problem.[107, 108]

4.2.1 Classifying Demand

The optimal lodging inventory for Maxwell will be highly dependent upon the distribution of the lodging demand. As shown in Chapter 3, the composition of demand is as important as aggregate-demand totals. Unlike the typical inventory problem that analyzes generated demand in a single period, the Air Force's demand analysis cannot be isolated to a single period. Lodging requests can be up to a year in length, and most are for more than one night. Additionally, courses are scheduled in overlapping patterns throughout the year, creating a demand mosaic of courses of different lengths and sizes. Demanders occupy the same rooms throughout their stay, requiring the inventory model to track demands across periods. A single-period inventory analysis that subtracts demand and supply cannot account for contract quarters and occupancy in each time period.[109] To accurately project on- and off-base costs, the inventory model must account for the daily-demand distribution's complicated composition, significant variance, and seasonality.

Consequently, we model lodging demand daily according to a distribution that reflects historical occupancy and course schedules (Section 5.1). The model accounts for the two major types of demand: scheduled and random. By combining scheduled and random demand, the inventory model provides an accurate picture of aggregate lodging

---

[107] Hillier and Lieberman, 2001, p. 962; Nahmias, 1982; Williams and Patuwo, 1999; Fries, 1975.

[108] Fries (1975) shows that a one-period perishable-inventory model is equivalent to a one-period stochastic-inventory model without expiration (the newsvendor problem), and consequently each period can be analyzed independently. For the Air Force's problem, however, the periods are not independent, because of a fixed inventory across all periods, correlated demands, and correlated placement decisions.

[109] Section 3.2.2 showed that excess-demand measures, even at the daily level, systematically underestimate contract quarters.

demand throughout the year, while preserving the demand composition and multiday demanders from the course schedules.

4.2.2 Accumulating Costs

The inventory model solves a cost-minimization problem (see the optimization formulas in Section 4.1.5) to determine the efficient inventory.[110] The model accounts for the annual costs incurred in operating on-base lodging facilities and purchasing contract quarters. This requires a decomposition of the Air Force's annual base-lodging budget to approximate the cost function. Currently, this decomposition to obtain a full understanding of the Air Force's lodging-cost function is not being done. By itself, it would represent a significant contribution to the Air Force's financial management.

We separate the costs into the categories listed in Section 4.1.2 as follows:

1) **Ordering/production costs:**
    a. Fixed facility costs—the costs of constructing y number of rooms, i.e., the single-year amortized value of constructing facilities to provide y rooms.
    b. Yearly operations and maintenance costs—the fixed and variable costs of operating and maintaining y number of rooms, a function of both y (inventory) and d (stochastic demand). These costs include maid service, the reservation system, linens, maintenance, and supplies.
2) **Holding costs.** Since the costs for providing an inventory level y are specified in 1a and 1b, holding costs can represent the salvage value of unutilized rooms. Space-available lodging provides a mechanism to salvage value from excess rooms by allowing priority-two occupants to purchase space that has already been provided by the government. The salvage value equals the lodging revenue generated less the marginal cost of the extra room. This dissertation focuses on

---

[110] The analysis solves for the least-cost room inventory based on the proposed facility-construction options. It does not solve for the optimal number of rooms. The construction options are derived from the number of rooms constructed under each phase of the SOC Lodging Plan.

priority-one demand and does not explore this idea, but it is an area for investigation in future work.

3) **Penalty costs.** Penalty costs are the contract-quarters costs of sending excess demand to local hotels. The per-unit contract-quarters price multiplied by the inventory model's projected annual contract-quarters usage will yield annual contract-quarters cost estimates. The decisionmaker must also consider other monetary and qualitative costs associated with off-base housing, such as transportation costs, decreased unit integrity, and force-protection concerns.

To provide a long enough period for comparing different inventory policies, the model compiles the *yearly* cost of running the lodging operation. Any cost that is a function of daily-demand flows will be model-dependent and is summed across all periods for one year.

4.2.3 Ordering

The Air Force's lodging inventory cannot be reevaluated every period; it is fixed in the short run. "No reordering" represents the reality of the problem facing the Air Force, since the average time from facility-construction decision to operable facility is approximately five years.[111] This is a distinct variation from the standard perishable-inventory model, in which the inventory decision is made in the same time horizon as inventories expire and demands are realized. For the Air Force, rooms expire on a daily basis, but the same number of rooms is available to meet demands in the next period.[112] The inventory choice is made once for the entire year and is not reevaluated between periods. The model thus determines the single best inventory to meet the entire year's demand.

---

[111] This lead time results from the government budget process, environmental review, contracting regulations, and an 18-month build (cited by AETC/CEPH).

[112] The number of available rooms is a function of the number of rooms in the facility stock and blocked spaces. The number of available rooms is not exactly the same from day to day, because blocked spaces vary from day to day.

4.2.4 Analyzed Time Step

Chapter 3 showed that aggregating parameters across time to simplify the analysis distorts analytic results. Consequently, the model's discretized time step is daily to capture phenomena occurring in short intervals, such as daily-demand variability and blocked spaces. A daily time step preserves the effect of demand spikes resulting from overlapping course and stochastic demands. A longer time step would require aggregating daily demand into averages, which would smooth demand spikes and underestimate contract quarters.[113]

4.2.5 Analytic Approach

This subsection weighs the merits of the two analytic approaches, optimization and simulation, and selects the better analytic model for addressing the problem. The optimization equations in Section 4.1.5 make an assumption that does not hold in our model: In the cost equation, shortages accumulate only in time steps when the stochastic-demand variable exceeds inventory.[114] Chapter 3 verified that contract quarters accumulate on days when demand does not exceed the available inventory, because of lodging's placement rules and movement restrictions. For our problem, the literature's model for accumulating shortage costs is oversimplified, cannot capture all occasions of contract quarters, and thereby understates cost. The accumulation of contract quarters is based on the ability of the lodging reservation staff to place demanders in on-base rooms for the duration of their stay, which requires placement considerations and movement restrictions that stratify individual days. It would be impossible to write an optimization equation to describe this behavior within daily discrete time steps.

As a result, simulation will be used to accurately model these placement and movement rules and to provide a more realistic estimate of the number of contract

---

[113] Section 3.2.1 showed that aggregating daily data leads to an underestimate of contract quarters.

[114] $c_2 \int_y^\infty (\xi - y)\, \varphi_D(\xi)\, d\xi$

quarters and total lodging cost. With a short list of feasible capacity-policy options, the simulation compares expected costs in each scenario and concludes a "best" inventory solution, albeit not an optimal one.[115] This is in line with the literature's discussion on simulation from Section 4.1.5, "Each possible policy is then tested in the computer's simulation of the model, and the appropriate policy is selected according to the objective function".[116] The simulation model generates costs for each facility-inventory scenario, such that the policy options are comparable.

Beyond selecting a "best" inventory, the simulated reservation placement system provides the capability to evaluate the costs of lodging's other micro policies. Managerial extensions for the model will be discussed in Chapter 7.

4.6 SUMMARY

This chapter has linked the literature on inventory models to the Air Force's capacity determination problem. Stripped of complexity, the Air Force's capital right-sizing problem mirrors the issue considered by the inventory-theory literature: determining an optimal inventory level that minimizes total costs for a given demand distribution. The literature review in Section 4.1 provided a description of the important functional components of all inventory models, historical modeling treatments for each component, and references to justify this dissertation's approach. Section 4.2 applied the literature to Maxwell AFB by outlining how each component will be modeled. This model differs from the traditional inventory-theory model in its treatment of shortages and the need to consider cross-period factors, leading to the chosen simulation approach. Chapter 5 will discuss how each component of the simulation is modeled.

---

[115] The simulation yields a "best" solution rather than an optimal one because it evaluates only a list of feasible policy alternatives. Finding the best solution among a list of alternatives does not guarantee the optimal solution.

[116] Arrow, Karlin, and Scarf, 1958, p. 17.

5. AN INVENTORY SIMULATION MODEL

This chapter provides a more detailed explanation of the inventory simulation model by focusing on the estimation and implementation of the model's components. Sections 5.1 through 5.5 discuss the individual components of the model: (1) estimating demand, (2) determining available supply, (3) generating on-base and off-base facility placements, (4) estimating cost functions, and (5) calculating total cost distributions from the simulation output. We outline how each component of the model is implemented, focusing mainly on methodology, while avoiding excessive detail such as the programming code. The chapter is organized to parallel the model's flow, illustrated in Figure 5.1. Section 5.6 verifies and validates the simulation model as an appropriate tool for determining the efficient lodging capacity at Maxwell AFB.

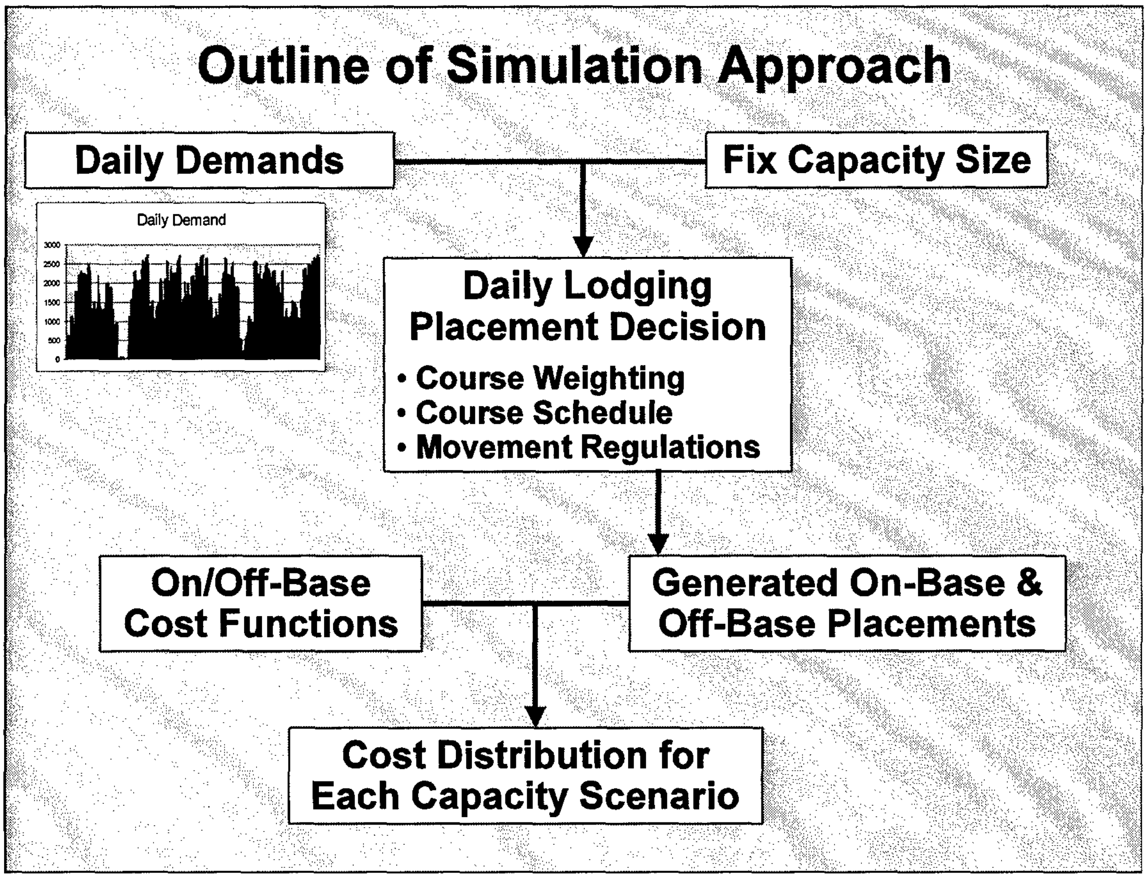


Figure 5.1 – Framework of Simulation Model

The model's objective is to evaluate the total lodging cost of different capacity scenarios for a given demand distribution and set of micro lodging policies. Figure 5.1 outlines the simulation framework and the functional components of the model. First, demands for the entire fiscal year are obtained from the course schedules and the residual-demand predictions (discussed in Section 5.1). Then, for each simulation run, the model fixes on-base capacity by selecting one of the facility scenarios generated by the Air Force's macro policy alternatives: current baseline, baseline + 1 additional facility, baseline + 2 additional facilities, or baseline – 1 facility.[117] With the inclusion of blocked spaces, this establishes the available supply of on-base facilities throughout the year (Section 5.2). Next, the simulation approximates the on-base and off-base lodging

placements for the given demand and available supply (Section 5.3). Lodging placements depend upon many factors, including total space, blocked rooms, course schedules, stochastic demand, the on-base/off-base movement policy, and other micro policies that govern on-base facility placements. The simulation accounts for these covariates in determining facility placements, thereby reproducing the way this function is performed by Maxwell's lodging reservation system. The model outputs daily totals for the number of individuals staying in on-base and off-base quarters. Finally, the cost functions are applied to estimate the annual total cost of the model-generated placements (Section 5.4). Because of the stochastic nature of demand and blocked spaces, the simulation is replicated many times for each capacity scenario to develop cost distributions rather than point estimates (Section 5.5). A comparison of capacity scenarios based on Air Force objectives will yield a "best" on-base facility level and an estimate of expected future costs.

5.1 MODELING DEMAND

For completeness, the inventory model must account for the daily-demand distribution's complicated composition, correlated demanders across days, significant variance, and seasonality. Most important, the demand analysis cannot be isolated to independent days. A single-period analysis that subtracts supply from demand will insufficiently account for contract quarters and will overestimate on-base occupancy in each time period.[118] The simulation model utilizes course schedules to account for individuals whose lodging requirement spans multiple days. As a result, the simulation retains the rigidities of individual demanders requesting the same room over multiple periods, thereby allowing the inclusion of AETC's movement restrictions.

First, the model computes the daily course-related demand, using the course schedules and projected attendance from EMS. Table 5.1 is a sample of the course listing

---

[117] For example, the simulation could evaluate the effect of closing building 157 at Maxwell AFB, University Inn, which is in serious disrepair.

[118] Section 3.2.2 showed that excess-demand measures, even at the daily level, underestimate actual contract quarters.

utilized by the model. The entire FY03 course listing is given in Appendix A. The listing is sorted by priority weighting to ensure that the model places the highest-priority courses first.

Table 5.1
Sample of EMS Course Listing

Course Name	Priority Weight	Start Date	End Date	Total
USAF SENIOR NCO ACADEMY	56	7-Oct-02	21-Oct-02	363
USAF SENIOR NCO ACADEMY	56	14-Jan-03	28-Feb-03	377
USAF SENIOR NCO ACADEMY	56	12-Mar-03	24-Apr-03	363
USAF SENIOR NCO ACADEMY	56	6-May-03	19-Jun-03	363
USAF SENIOR NCO ACADEMY	56	19-Jul-03	5-Sep-03	363
AEROSPACE BASIC COURSE	55	1-Oct-02	4-Oct-02	644
AIR AND SPACE BASIC COURSE	55	14-Oct-02	8-Nov-02	644
SQUADRON OFFICER SCHOOL	55	3-Nov-02	11-Dec-02	390
TOPS IN BLUE	55	4-Nov-02	5-Nov-02	32
AIR AND SPACE BASIC COURSE	55	19-Nov-02	19-Dec-02	611
SQUADRON OFFICER SCHOOL	55	5-Jan-03	7-Feb-03	390

NOTE: Some EMS course data (course number; class number; enlisted, officer, and DV officer totals; base preference) are excluded for simplicity of presentation.

Total course demand is the daily summation of all individual listings in EMS. Notionally, each course can be thought of as a block with a height equal to the total number of students and a width equal to the course length. The simulation places each block (course) individually in order of course weighting. Course demand closely emulates total priority-one lodging demand, as shown in Figure 5.2.

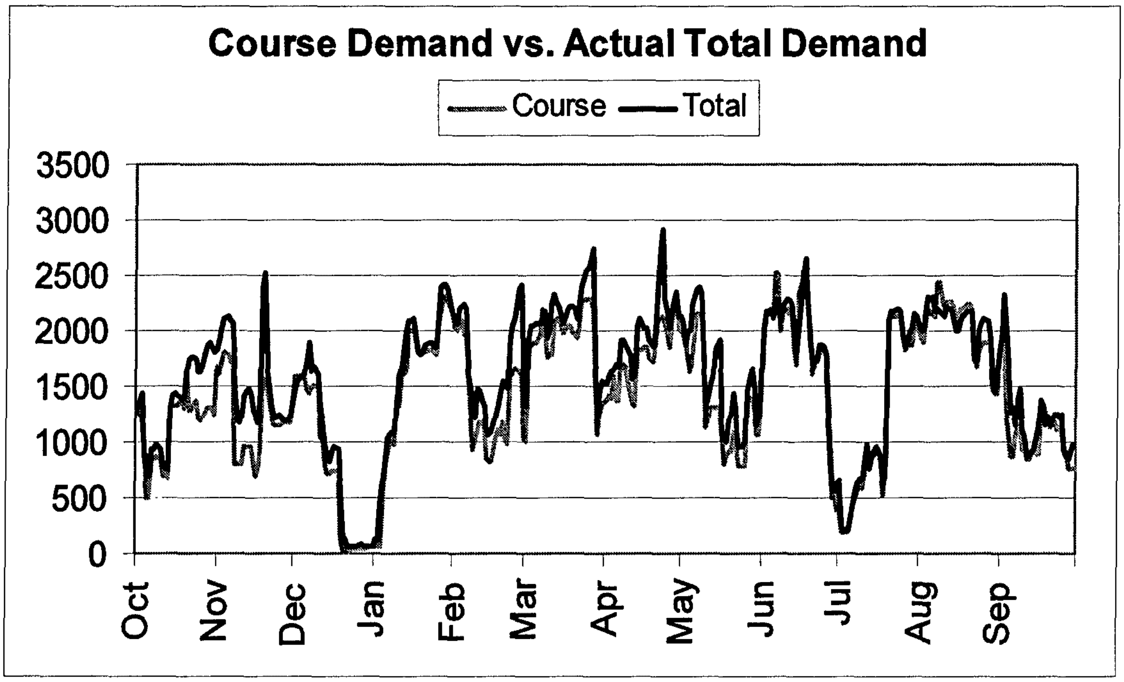


Figure 5.2 – Actual FY03 Demand Versus EMS Course Demand at Maxwell and Gunter

The residual demand is the difference between the projected course demand and the actual priority-one lodging demand (see Figure 5.3). Residual demand occurs for a variety of reasons, the most important being individual TDY personnel at Maxwell.[119] On nearly all days, actual demand exceeds the projected course demand, yielding a positive residual demand. On roughly 10 percent of the days, however, course demand overestimates the actual number of on-base demanders, yielding a negative residual demand. Course-demand projections can overestimate actual attendees when some openings in a course are not filled. The lodging operation must handle no-shows in real time, incurring the side effect of reduced on-base efficiency, but the model is unable to capture no-shows because no data were available on actual versus projected attendees for

[119] Section 2.4 defines the categories of non-EMS demands (p. 26).

FY03 courses.[120] For the purpose of econometrically estimating residual demand, the negative demands are set equal to zero.[121] It is not necessary to estimate the actual residual demanders (i.e., TDY personnel), because we subtract course demand from the actual on-base occupancy. This approach enforces the actual daily occupancy while still maintaining the correlation of individual demanders across days through the course schedules.

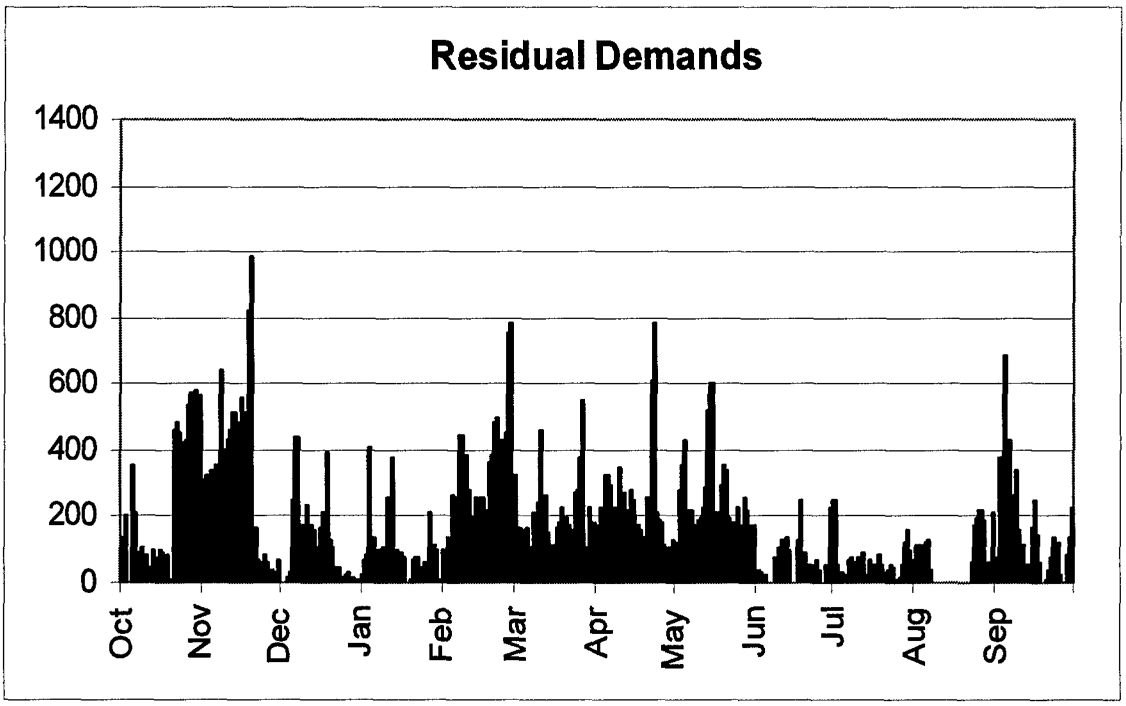


Figure 5.3 – Actual Residual Demand at Maxwell and Gunter

Unlike the deterministic course demand, residual demands, particularly by TDY personnel, follow a more random generating process. Therefore, the model estimates

[120] EMS began recording planned versus actual lodging occupants by course in FY04. Including this information in the model could improve future analysis by allowing better estimation of residual demand.

[121] Since the simulation places residual demand after placing course demand, it is impossible to incorporate negative residual demands by subtracting from the already-placed course demanders. Eliminating negative residual demands results in an overestimate of total demand; however, the overestimate is small and does not affect model results, because the negative differences are small, usually less than 50 rooms, and they occur on only a small fraction of the total days (less than 10 percent).

residual demand through an econometric prediction model estimated from the daily data in Figure 5.3. Demands are estimated using a linear model for the square root (the variance-stabilizing transformation for the Poisson distribution) of the residual demand.[122, 123] The linear model allows the residual demand to be dependent upon month, day of the week, and correlated error terms from an AR(1) autocorrelation process. Therefore, demand estimates are autocorrelated and vary by time of year and day of the week, as is apparent in Figure 5.3. (Appendix C explains the model estimation methodology step by step and includes the regression-parameter estimates.) Figure 5.4 compares an example of the regression model's simulated demands with the actual demands from Figure 5.3. The closer the points are to the y = x line, the better the model estimation is. The model is an imperfect, yet reasonable, predictor for the actual residual demand data.[124]

---

[122] The Poisson distribution is often used to estimate the number of occurrences in a finite amount of time. This makes it a good model for estimating the daily residual demand (Hillier and Lieberman, 2001, p. 846).

[123] A Poisson-distributed random variable, S_i, can be estimated through a linear-regression approximation: $\sqrt{S_i} = B'x + \varepsilon$ when S_i is sufficiently large ($S_i > 15$) (McCullagh and Nelder, 1989).

[124] Because new residual demands are generated for each model run, the results are not sensitive to an exact prediction of residual demand. The simulation evaluates the policy options with demand uncertainty.

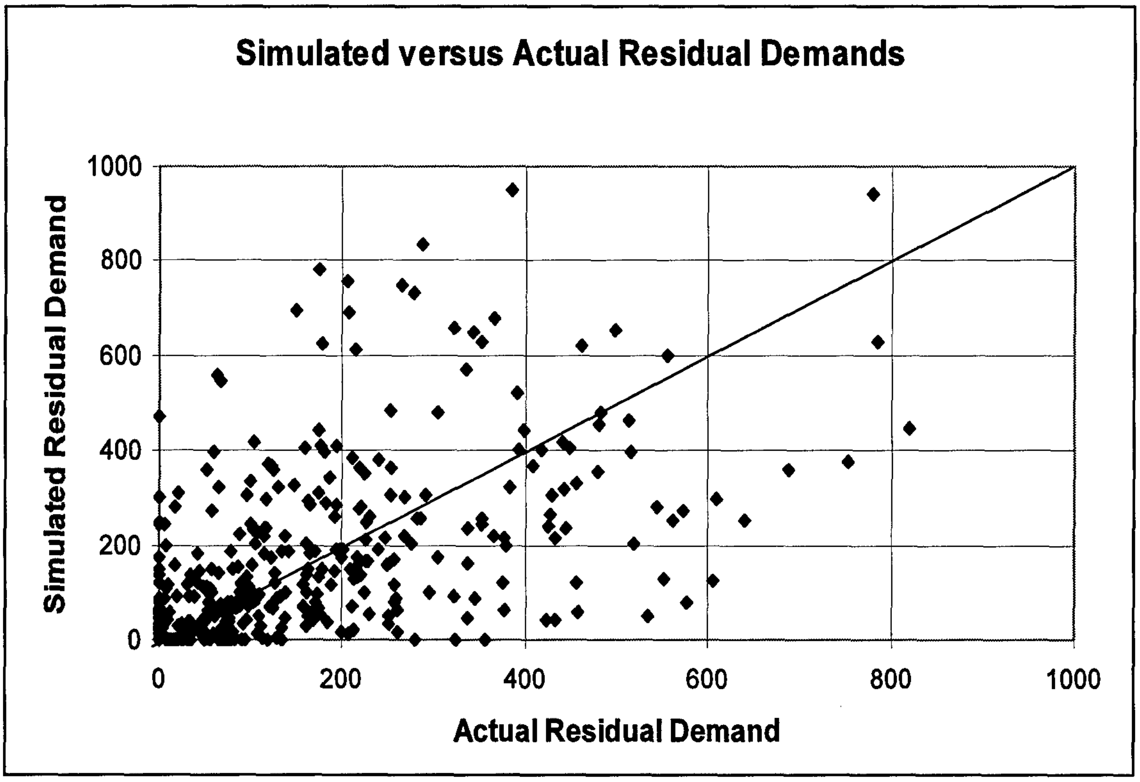


Figure 5.4 – Comparison of Simulated with Actual Residual Demands

Once the residual demands are randomly generated, the model correlates them across days. Residual demanders stay for multiple days and are subject to AETC's movement restrictions. As with course demand, placing each residual demander one day at a time would overstate the effectiveness of on-base quarters and underestimate contract-quarters requirements. To correct for this, stay lengths are imposed into the generated residual demand. The LTS occupancy data did not track individual stay lengths, so this analysis assumes a plausible stay-length distribution using the discrete probabilities from a Poisson distribution with a mean stay of four days (Figure 5.5).[125, 126]

[125] Four days was assumed to be a suitable mean stay length, allowing for stays as short as one day and as long as seven days. Sensitivity analysis was performed for the assumed mean stay length, with little effect on model results. The assumed parameter has little effect because the constrained stay lengths are lower than the Poisson distribution would predict (Figure 5.5), and changes to the Poisson parameter have little effect on the model's skewed distribution.

However, the Poisson stay lengths are applied to the generated residual demands subject to the constraint of not exceeding the generated demand on any given day.[127] The generated residual-demand values are not altered to enforce the stay-length distribution. As a result, the distribution implemented in the model is skewed to lower stay lengths than those obtained using the Poisson distribution. Figure 5.5 compares the stay lengths generated by the model with those from the Poisson distribution.

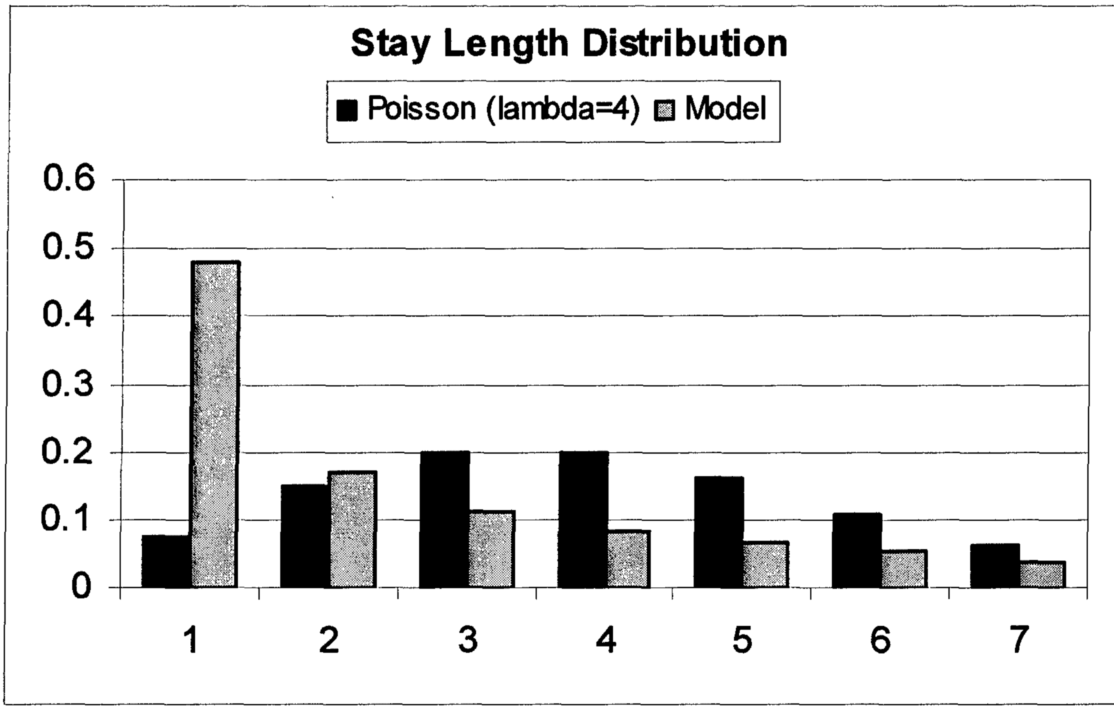


Figure 5.5 – Model-Implemented Versus Poisson-Distributed Stay Lengths

[126] The density for x = 0 is dropped because stay length cannot equal zero. The density of x >7 is dropped because the cumulative probability is 3 percent. Consequently, the model's longest stay length is seven days.

[127] Periods of low projected demand restrict the number of long-staying occupants that would overlap on these low-demand days. For example, if the generated residual demand on day 5 is zero, the highest number of days a person could stay on day 1 would be 4. Likewise, on day 2, the highest number would be 3. The resulting stay-length distribution will be skewed to lower stay lengths than the Poisson-distributed densities (Figure 5.5).

Since the model's resulting stay distribution more closely mirrors the one-day-demander case, the model underestimates contract quarters resulting from longer TDY stays. This is probably the primary source of underestimated actual FY03 contract quarters in the simulation model, but it is impossible to explicitly determine without more-detailed data on individual TDY demands and their stay lengths.

Combining scheduled and random residual demand provides the inventory model with an accurate picture of aggregate lodging demand while preserving the demand composition and multiday demanders from the course schedules. Preserving the demand composition and stay length allows the simulated reservation system to more accurately project on-base and off-base placements by tracking individual demanders.

5.2 CAPACITY SCENARIOS AND ESTABLISHING SUPPLY

The model fixes total supply by selecting one of the facility scenarios, based on the Air Force's policy alternatives: FY03 facility baseline, baseline + 1 additional SOC facility (phase II), baseline + 2 additional SOC facilities (phase III), etc. The user may specify exactly which facilities are included in the analysis.[128] Additionally, the model provides the capability to evaluate the effect of closing outdated facilities after additional SOC facilities are opened and the contract-quarters issue subsides.[129] The chosen capacity establishes the total supply for on-base facilities throughout the year.

After establishing total supply, the model includes the effect of blocked spaces to calculate daily available supply. This analysis separates blocked spaces into two categories: scheduled renovations and unpredictable blockages. Since scheduled renovations are planned during low-demand periods, the model inputs scheduled facility blockages deterministically to retain the user's chosen scheduling. The average number of days blocked deterministically for each facility is 25. For the remaining days, blocked spaces are modeled stochastically. The decision on whether blocked spaces would be

---

[128] Facility lists are given in Section 2.3.1.

[129] The model can evaluate the effect of closing building 157, University Inn, which is in serious disrepair, or the shared-bath facilities that are deemed substandard.

modeled deterministically or stochastically for a given day was made qualitatively, on the basis of demand projections for that day, the time of year, the length of consistent blockage for a facility, and the percentage of total facility rooms being blocked. For example, if all rooms in a facility were blocked for two weeks during a low-demand period and were reopened before demand increased again, those blockages were presumed to have been purposely scheduled and were modeled deterministically. Conversely, short-duration single-room blockages in a facility were stochastically modeled. While the modeling distinction affects available supply, the most important factor is that every blocked room in the occupancy data is modeled either deterministically or stochastically.

On most days, the blocked spaces for each facility are modeled stochastically. For all but one facility type, the data revealed a small number of blockages (i.e., single rooms or a small collection of rooms) on random days throughout the year. The model utilizes a binomial distribution to estimate daily blockages for each facility type.[130] Maxwell's shared-bath VOQ facilities (ORM1S) are the notable exception. The shared-bath facilities, which in the data cannot be separated into individual facilities, had a higher average daily number of blocked rooms, and the pattern was more variable. These rooms were modeled using a bootstrapping sampling approach from the actual-blocked-room data.[131] The bootstrap sampling was done in two-day increments to capture some of the autocorrelation in the actual blocked-spaces data.

---

[130] The binomial distribution generates event counts based on the number of trials, n, and the event probability for each trial, p. This makes it a good distribution for estimating blocked spaces, because the underlying probability of blockage can be estimated from Maxwell's blocked-spaces data, and the number of rooms for each facility is known. For this analysis, the binomial distribution's assumption of independence is tenuous, since once a blocked space occurs, it becomes more likely that another blocked space will occur on the following day. Practically, the violation of this assumption will not affect model results because there are typically only zero or one blocked spaces per day,, so it affects only one room per facility.

[131] Bootstrapping is a statistical sampling technique in which stochastic outcomes are generated by randomly selecting observations from the actual data. All consecutive two-day combinations from the actual blocked-spaces data form an observation list from which to sample. The data are divided into two-day clusters to preserve some of the autocorrelation. Each two-day combination has equal probability of selection. The model randomly samples from the list until the blocked spaces for all stochastically generated days are filled.

The model combines the days with stochastically generated blocked spaces, which change for each model run, with the deterministically determined days. The blocked spaces are then subtracted from the total facility space in each facility type to yield the number of rooms available for occupancy each day.[132] Blocked spaces are eliminated from supply before the simulated reservation system begins placing demands, so the system does not react dynamically to maintenance problems in the same way lodging management actually does. This causes the model to overstate the efficiency of handling the real dynamic effect of blocked spaces. Once blocked spaces are included, the model passes the daily number of available rooms to the simulated reservation system.

5.3 SIMULATED RESERVATION SYSTEM

The simulated reservation system merges available supply and demand to approximate on-base and off-base lodging placements. Lodging placements depend upon many factors, including total space, blocked rooms, course schedules, stochastic demand model, the on-base/off-base movement policy, and other micro policies. The simulation accounts for these covariates in determining facility placements, replicating the reservation function at Maxwell.

The simulation places course demands and then residual demands into the available rooms. Courses are placed one at a time in descending priority order, starting with the highest-priority course.[133] The course-placement algorithm follows rules that replicate those exercised by Maxwell's reservation supervisor. In the interest of maximizing on-base occupancy, base reservationists place personnel in any facility that meets the minimum AFI 34-246 lodging standards, regardless of base preference or a course's special placement considerations. The model attempts to maintain course

---

[132] Subtracting the number of blocked rooms from the total facility space has the unfortunate consequence of always blocking the same rooms first. For example, an 80-room facility would always block room 80 first, then 79, 78, and so forth. This was a modeling simplification that leads to overstating the efficiency of on-base quarters. If the blocked spaces occurred randomly to rooms throughout the facility, long-term reservations in those rooms would be affected.

[133] The weighting order is based on the AU course-weighting scheme in Figure 2.8. The entire course listing with course weights is given in Appendix A.

integrity by placing course attendees in consecutive rooms.[134] While not guaranteed, a course's site or facility preferences are considered, and the simulation replicates those preferences:

1) SNCO Academy is placed in Gunter's private-bath VAQ, followed by Gunter's shared-bath VAQs, Gunter VOQs, and finally Gunter DVEs. The primary goal is placement on-base at Gunter.
2) NCO Academy is placed in Gunter's shared-bath VAQ, private-bath VAQs, VOQs, or DVEs. The primary goal is to be on-base at Gunter.
3) Because of their long stays, international officers attending Maxwell's PME courses are placed in VOQs with kitchens. When such rooms are unavailable, the officers are placed in any private VOQ room or, lacking that, a shared-bath VOQ.
4) SOS students are placed in private-bath facilities on or near the SOC campus; if none are available, students are placed in Maxwell's other private-bath VOQs; the last option is Maxwell's shared-bath facilities.
5) ASBC students are placed in Maxwell's shared-bath VOQs, then ASBC-preferred private-bath VOQs, then Maxwell's other private-bath facilities.
6) JAG courses prefer building 680 for its Internet connectivity. If building 680 is unavailable, students are placed in Maxwell's private-bath VOQs or shared-bath VOQs.

All other courses are placed according to the rank of the participants and the course's base preference. Courses that prefer Gunter are placed in the VOQ or VAQ facilities that correspond to the attendees' rank, but if space is unavailable at Gunter, reservations are made at Maxwell. For courses that prefer Maxwell, colonels and above are placed in Maxwell's DVOs and officer suites. Other officers are placed in Maxwell's private-bath facilities, then in Maxwell's shared-bath VOQs, then in Gunter's VOQs.

---

[134] For a given course, the model algorithm checks room availability one facility at a time in order of the course's facility preference. Course attendees are placed in neighboring rooms when available. Maintaining course integrity is not a hard constraint, however; when neighboring rooms are not available, course attendees are placed anywhere on-base before contract quarters are utilized.

Enlisted personnel are placed in Maxwell's shared-bath VOQs, then private-bath VOQs, then Gunter's enlisted and officer facilities.

When the simulation attempts to place course attendees on-base, it first tries to reserve an available room for the entire stay length, checking each room individually in order of facility preference. If a room is unavailable at any point during the attendee's length of stay, the room is rejected and the next room is checked. When there is insufficient space to place all attendees on-base for the entire course length, the model utilizes a combination of on- and off-base quarters that maximizes on-base occupancy subject to the restriction of moving only once and residing in each place for at least five days. If no feasible combination of on- and off-base quarters exists, attendees are placed in contract quarters for the entire stay. Once all of a course's attendees are placed in on-base quarters, off-base quarters, or a combination of the two, the simulation places the next course.

After all entries in the course listing are placed, the simulation places the generated residual demands.[135] Stay lengths for residual demanders vary from one to seven days. Starting at the beginning of the fiscal year, the simulation places the longest stays first, followed by the next longest, until all residual demands initiating on a given day are placed.[136] The simulation then moves to the demands initiated on the following day, again placing the longest stays first. Placing the residual demands in order by longest stay length is most efficient because it utilizes the longest availabilities for the longest requirements. This efficiency will overstate actual TDY reservation placements that are based on individual reservations and proceed more randomly. For facility preference,

---

[135] While placing course demands before residual demands approximates the real reservation system (Section 2.4.2), the model overstates the reality by placing *all* courses before placing any residual demands. In reality, residual demanders who have made their reservations long in advance and are in the reservation system when courses are placed would maintain their room placements, decreasing the efficiency of the course-placement process. This effect is small, because courses are scheduled in advance of nearly all residual demanders, and residual demand is comparatively small.

[136] For example, starting on October 1, all seven-night stays are placed in the lodging system, where individuals reserve the same rooms from October 1 through October 7. In turn, the simulation places the six-night stays (October 1 through 6) and all other stay lengths, finishing with demanders staying a single night (October 1). Next, the simulation places residual demands initiating on October 2, again starting with the seven-day stays.

residual demands are first placed in Maxwell's private-bath facilities, followed by Maxwell's shared-bath facilities, and finally Gunter's facilities.

When the residual demands are placed, all priority-one lodging demands have been met in either on-base or off-base quarters. The simulation has approximated the actual reservation system and has generated estimates for the on-base and off-base totals based on the input demand and available space. The estimated facility placements can now be used to generate total cost distributions based on the on-base and off-base cost-estimating functions.

5.4 COST-ESTIMATING FUNCTIONS

To determine the efficient facility capacity, the inventory model solves for the least-cost room inventory of the proposed facility-construction options. The model does not solve for the exact number of rooms that minimizes expected total cost. The least-cost inventory will minimize total annual lodging costs, which include the cost of on-base facilities and off-base contract quarters. The total on-base cost includes the annual operating costs for on-base facilities, both appropriated and nonappropriated, and the capital cost of additional facility construction. Off-base costs are a direct function of the per-unit contract cost and the number of generated off-base placements.

In total, the model calculates five separate cost categories (see Subsections 5.4.1 through 5.4.5): off-base contract-quarters costs, nonappropriated fund (NAF) operating costs, direct appropriated funding costs, new-facility capital costs, and the outsourced civil-engineering contract that provides services to lodging facilities.[137] The last four categories are separate funding sources for constructing, operating, and maintaining on-base lodging. Lodging's on-base cost function is split among different organizations and funding sources, making it difficult to estimate the total on-base-lodging cost. We recommended that AETC/FM review the cost estimates to ensure that all relevant costs

---

[137] Air Force lodging receives funding from both appropriated and nonappropriated sources. Air Force Instruction 65-106 governs the use of both types of funds.

are included and the estimations are consistent with AETC estimates.[138] This analysis collects historical cost data and estimates cost functions for each cost category. All individual costs are summed to generate a combined on-base-cost estimate, which is presented in Section 5.4.6. Some operating costs depend on the number of on-base occupants or the number of on-base facilities. Each subsection describes the items included in the cost category and the estimation function used in this analysis. Appendix D provides additional methodological discussion of how each cost is estimated.

5.4.1 Contract-Quarters Costs

Methodologically, contract-quarters costs are the simplest of the four cost categories to estimate. Our model uses the FY03 average per-unit contract-quarters cost of $54 to estimate total contract-quarters expenditures. While the actual contract-quarters price varies between $45 and $57, the average expenditure price was consistent throughout FY03.[139] Contract-quarters costs are estimated by multiplying the per-unit cost by the predicted annual contract-quarters totals from the simulation. It is possible that Maxwell's lodging policies, in particular the construction of new facilities, could affect future contract-quarters prices.[140] This analysis does not consider this effect; it assumes the contract price remains constant at $54:

*Contract-quarters costs = $54 * contract-quarters*

Contract-quarters costs consist of only the actual hotel cost of sending personnel off-base. They do not include other monetary and nonmonetary costs associated with utilizing contract quarters, such as off-base transportation, higher per diem rates, force protection, unit integrity, or inconvenience. Decisionmakers should qualitatively

[138] After this analysis was completed, we discovered that per diem rates for food are different for on-base and off-base lodging. This cost difference was not included in the analysis, but it would affect capacity determination. In general, the inclusion of these costs would make additional construction relatively more desirable.

[139] AETC aggregated occupancy spreadsheets.

[140] Maxwell's decreased utilization of off-base quarters could drive down prices because of lower market demand for off-base hotels. Alternatively, the negotiated contract price could increase because the base would lose market power, which has allowed it to negotiate below-market prices.

consider the indirect costs of utilizing off-base quarters at the levels predicted by the model.

5.4.2 Nonappropriated-Fund Costs

NAF make up the bulk of lodging's annual operating expenditures. The majority of nonappropriated revenues are generated through the individual room charges (~$25/night).[141] The funds to pay for these room charges typically come from appropriated TDY accounts but are redesignated nonappropriated upon receipt by lodging. Lodging uses NAF to pay for a wide variety of activities, from personnel costs to furniture. The lodging operation maintains detailed monthly operating statements on the use of NAF in each funding category. These monthly operating statements form the basis for cost estimation by major funding category: sales, personnel, support, material, entertainment and promotion, other operating expenses, amortized expendable equipment, depreciated heavy equipment, and facility depreciation.[142] The analysis includes 33 operating statements from October FY02 through June FY04. Monthly expenditures are converted to constant FY03 dollars, using the consumer price index.[143]

Each category's monthly costs are first analyzed to separate fixed and marginal cost components. Fixed costs are those that do not vary with on-base occupancy, and marginal costs are those that increase with occupancy. If monthly costs vary by occupancy, the relationship is estimated linearly with an ordinary-least-squares (OLS) regression. Second-order polynomials were tested to see if costs varied nonlinearly with occupancy, but none was statistically significant. Next, the analysis investigates whether cost increases are linked to newly constructed facilities beyond the marginal cost

---

[141] Charges vary by facility type and fiscal year and are set by each major command.

[142] Nonoperating costs, such as the Air Force assessment, are not included in this cost analysis because they are transfer payments and do not represent an actual expenditure for operating Maxwell's lodging operation. This analysis focuses on the actual costs incurred by operating the on-base lodging facilities.

[143] Amortization and depreciation costs were not converted to real dollars because they do not represent actual monthly outlays.

increases associated with the increased occupancy.[144] This analysis compares the monthly expenditures before and after the opening of building 681 in January 2004 and estimates any differences. Thus, monthly cost estimates for each category include fixed costs and, if significant, costs that vary with occupancy and new-facility construction.[145]

Sales Profit

Sales include the profit generated from selling drinks and snack food at the front desk, in suites, and at Gunter's lodging operated mini-store. Unlike the other categories, sales represent revenue and reduce the overall government cost burden of running the lodging operation. The monthly sales profit varies with occupancy and is estimated by the function:

$$Sales = \$979.30 + \$.0194684 * Occupants$$

Each additional occupant generates, on average, an additional 2 cents of sales profit. This cost function is the best linear unbiased estimator (BLUE) for the sales profit over the relevant range of occupancy.[146] However, caution must be taken in using the equation to make out-of-sample predictions. Specifically, the estimation equation produces the erroneous result that sales profits will be $979 when occupancy is zero. But since this analysis uses the estimated function to project sales profits when on-base occupancy is high (greater than 15,000/month), an estimator that includes a nonzero constant is generally acceptable.[147]

---

[144] This could occur if there are fixed operating costs associated with a new facility that would not be captured by simply projecting the costs from the increased on-base occupancy. As an example, a new facility might require additional full-time maintenance or housekeeping staff beyond that required for the facility's additional occupancy.

[145] Detailed cost-estimation information for each category is presented in Appendix D.

[146] The Gauss-Markov theorem proves that OLS is the BLUE under the assumptions of the classic linear-regression model.

[147] A no-constant regression model could have been used to estimate these data, but such models lose the desirable properties of OLS (BLUE) by constraining the line through the origin. "Obtaining an estimate for B1 [slope estimate] using regression through the origin is not done very often in applied work, and for good reason: if the intercept $\beta_o \neq 0$ then β_1 is a biased estimator" (Wooldridge, 2000, p. 59).

Personnel Costs

Personnel costs include the payroll and benefit expenses of hiring the NAF employees to run the lodging operation[148]—the lodging administration, reservation staff, front desk clerks, maids, etc. While the majority of the personnel are full-time, flex staff are utilized to meet the higher labor demands of surge-occupancy periods.[149] This flexibility allows labor expenses to vary with occupancy, whereas in most businesses, labor expenses are typically fixed in the short run. The monthly personnel costs are estimated by the function:

$$Personnel = \$314{,}981 + \$1.635893 * Occupants + \$19{,}222 * New\,SOC\ Facility$$

This function reveals a large fixed cost, the cost of the full-time lodging staff that does not change month-to-month (e.g., lodging administration, reservation staff, desk clerks, and full-time maids).[150] Personnel costs increase by approximately $1.64 for each on-base occupant, representing the marginal cost increase. These variable costs are those for the part-time or flexible lodging staff, whose hours are variable and can be increased during periods of high occupancy. The fixed-cost increase for each additional SOC facility results from the additional full-time personnel required to operate and maintain a new facility, independent of the personnel costs associated with increased occupancy in the facility. For example, opening a new facility requires hiring additional maids dedicated to cleaning rooms in it.

---

[148] Personnel costs include overall labor expenses: wages, retirement plans (thrift savings plan and 401K), employer's share of FICA taxes, employer's insurance costs, employee training, workers' compensation, sick leave, vacation, etc.

[149] 40 percent of maids are flex staff, meaning that they are called in during high-demand periods or when other personnel are on vacation.

[150] As with to the sales profits, out-of-sample predictions using the cost functions are dangerous. The cost functions are the best linear predictors of the monthly personnel costs over the relevant occupancy ranges.

Support Costs

Approximately 80 percent of monthly NAF support costs are attributable to the credit-card surcharge, which is 3 to 3.3 percent of total credit-card revenue. The remaining 20 percent of support costs are monthly surcharges from base services for budgeting and human-relations support to hire, fire, and maintain records for lodging personnel. Support costs are directly related to occupancy through the credit-card surcharge and are estimated by the function:

$$\mathit{Support} = \$29{,}808 + \$.3714188 * \mathit{Occupants}$$

A portion of the fixed monthly charge is attributable to the finance and human-relations monthly surcharges, which are approximately constant month-to-month. The remaining fixed and marginal cost components are directly related to the credit-card surcharge.

Material Costs

Material costs include supplies, maintenance and repair, expendable equipment, postage, subscription charges, and amenities.[151] Unexpectedly, monthly material costs show no increase with occupancy or new-facility construction and are therefore estimated with the mean monthly cost:

$$\mathit{Material} = \$43{,}801$$

Entertainment and Promotion Costs

Entertainment and promotion expenses include complimentary items and advertising. Together, they account for a small fraction of overall lodging costs, roughly a few thousand dollars per year. Entertainment and promotion expenses are not correlated with on-base occupancy or new construction and are estimated with the average monthly expenditure:

---

[151] Material costs include expendable equipment that is not amortized (i.e., has less than a two-year useful life or costs less than $2,000).

Entertainment and promotion = \$392

Other Operating Costs

Other operating expenses consolidate miscellaneous expenses, such as uncollectible returned checks, taxes and license, flowers and decorations, insurance, and telephone charges. The largest expense (~80 percent of the total) is the telephone service charges. These costs were not correlated with occupancy or new-facility construction and are estimated with the average monthly expenditure:

Other operating = \$16,893

Amortization and Depreciation

The final three line items in the monthly operating statements are not actual executed expenditures for each month. These items account for the monthly amortized and depreciated expenses for large capital expenditures.

- **Amortization of expendable equipment,** typically equipment that lasts two years or longer and costs \$2,000 or more. This includes bulk purchases of VCRs, TVs, vacuum cleaners, etc.:[152]

  Amortization Expendable Equipment = \$44,513

- **Equipment depreciation,** typically for heavy equipment that is depreciated over a longer term.:

  Equipment Depreciation = \$18,808

- **Facility depreciation,** the depreciation of facilities purchased with NAF:[153]

---

[152] There is a distinction between larger purchases of expendable equipment that are amortized and smaller expendable-equipment purchases that directly impact the expense statement under material costs.

[153] Since most lodging facilities are constructed with appropriated dollars, this depreciation category includes only lodging-administration facilities and TLFs. TLFs have been eliminated from this analysis, leaving just the cost of lodging-administration facilities. It is unclear which administrative facility this represents, because the lodging administration is located in building 157, a VOQ facility.

Facility Depreciation = \$3,782

Maxwell's lodging operation receives large NAF grants to perform soft-good and hard-good renovations on several facilities each year.[154] Maxwell's services office amortizes the equipment in the NAF grants over the useful life of the renovated item and records the cost in one of the three categories above on the monthly operating statements.[155] Soft-good facility renovations are completed every five years and include everything in the room except hard furniture, i.e., bedspreads, carpeting, drapes, and chairs. Hard-good renovations, or "whole room concepts," are performed every ten years, replacing everything in the room.

Capturing facility renovation costs is an important part of estimating the overall cost of running the lodging operation. This analysis uses the average amortized monthly expenditures, which include the amortized value of renovations over many years, to expense the renovation grants. The consolidated monthly figures provide a good estimate for the annual expense of NAF facility renovations on the FY03 facility stock. The additional cost for NAF-funded renovation grants on newly constructed facilities will be included in the capital-cost estimates in Section 5.4.4.

Total Nonappropriated-Fund Costs

Accumulating all NAF costs together, we find that sales revenues, personnel costs, and support costs are the only categories that vary with occupancy, and personnel costs also varied with new-facility construction. Annual cost estimates for these categories depend upon the model's output for on-base occupancy and facility construction. For the remaining categories, monthly estimates are expanded multiplicatively into annual costs.

Figure 5.6 compares the model's cost estimates with the actual annual NAF costs in FY02, FY03, and FY04. The estimates are good predictors of the annual expense by

---

[154] The funds for these grants come from retained profits and assessed surcharges from all lodging operations throughout AETC.

[155] The services office uses a program that automatically amortizes/depreciates the expense. Personnel enter the cost and type of item, and the program outputs the amortized monthly cost and term, which are then entered on the monthly expense statements.

category and in total. For comparison, the estimates that required occupancy or new-facility-construction data were computed in two different scenarios: (1) using the FY02–FY03 average monthly occupancy of 44,025 and no new construction, and (2) using the FY04 average monthly occupancy of 49,093 and one additional facility. The first scenario resembles the situation and thus costs in FY02 and FY03, while the second scenario more closely resembles FY04. The estimates from the two different scenarios reveal that the model estimates mirror the higher annual costs in FY04, a year with higher on-base occupancy and a new SOC facility, whereas the first scenario accurately predicts total costs for FY02 and FY03.

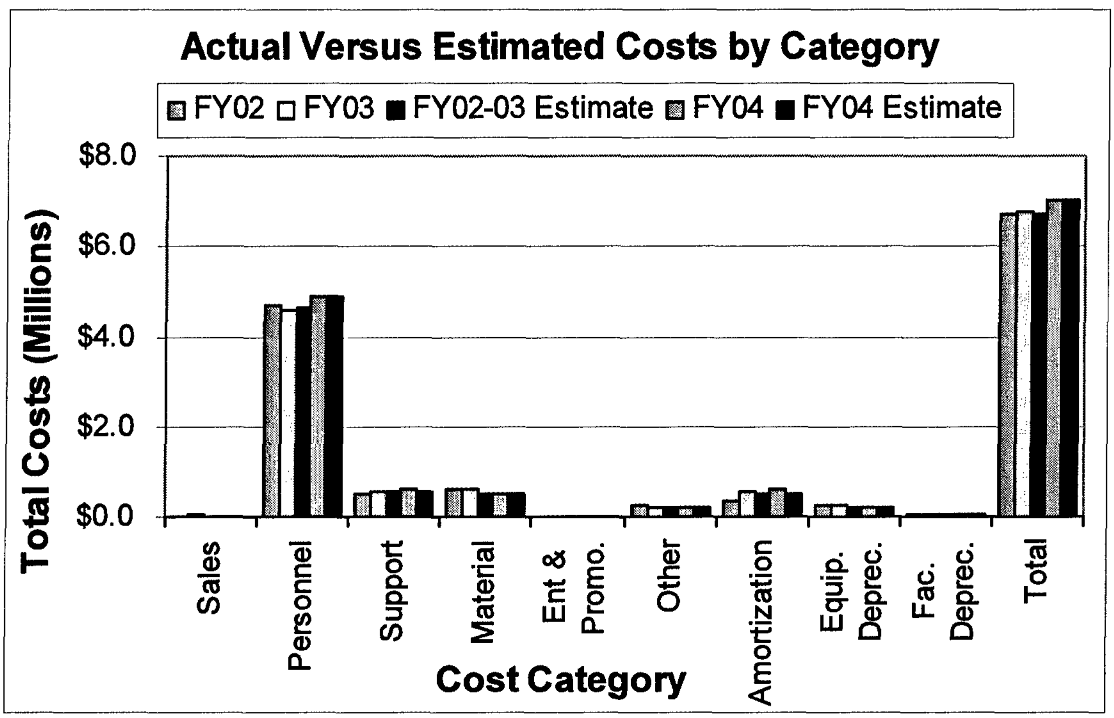


Figure 5.6 – Actual Versus Estimated Costs for Maxwell and Gunter, by NAF Cost Category

Table 5.2 presents the numerical cost totals from Figure 5.6, by category. Again, the estimates are good approximations for the actual costs in each cost category and in the overall NAF totals.

Table 5.2
Actual Versus Estimated Annual Costs by NAF Cost Category for Maxwell and Gunter

	Actual Costs (FY03 dollars)			Model Estimates (FY03 dollars)	
	FY02	**FY03**	**FY04**	**FY02-03 Scenario**	**FY04 Scenario**
Revenue					
Sales	19,331	26,962	20,261	22,037	23,221
Costs					
Personnel	4,711,755	4,574,945	4,899,022	4,644,014	4,916,501
Support	527,862	564,043	597,741	553,917	576,505
Material	592,348	604,603	526,149	525,614	525,614
Entertainment and promotion	2,988	3,904	8,070	4,707	4,707
Other	231,642	191,476	206,527	202,710	202,710
Amortization	381,549	569,017	591,764	534,154	534,154
Equipment depreciation	263,158	232,205	194,323	225,702	225,702
Facility depreciation	47,748	45,213	42,477	45,389	45,389
Total	6,739,719	6,758,444	7,045,812	6,714,169	7,008,061

NOTE: FY04 totals are estimated by inflating 9-month totals to 12-month totals.

Combining each category's cost function, total NAF expenditures are estimated by the function:

$$Total\ NAF\ Costs = \$5{,}663{,}995 + \$1.9878434 * Occupants + \$19{,}222 * NewSOC\ Facility$$

The majority of annual NAF costs are fixed, and cost changes for additional occupants or a new facility are only incremental. These marginal cost dependencies are related predominantly to personnel costs, whereas most other cost categories are

independent of changes in monthly occupancy or new-facility construction. It is important to note that many of these fixed operations costs are anchored to the current size of the on-base lodging operation. On-base occupancy could increase beyond current operational thresholds, requiring additional costs in categories thought to be fixed. As an example, the lodging administration has been sized for an on-base operation serving approximately 600,000 occupants per year. Marginal changes to this occupancy level may have no effect on the size of the administration, but at some point, increasing on-base occupancy will necessitate additional operations costs, such as the hiring of an additional reservationist. It seems reasonable to assume that for the same demand level, the size of the lodging administration would remain relatively constant whether personnel are lodged on- or off-base, because off-base personnel are still processed and tracked by lodging management. However, changes to the aggregate demand level would probably impose an additional burden.

5.4.3 Appropriated Fund Costs

There are two main categories of appropriated funding used for lodging: government purchase card (GPC) and Air Force Form 9, request for purchase.

Government Purchase Card

The GPC provides appropriated funds to purchase small items for the lodging operation. The annual GPC budget is fixed from year to year, and lodging management controls the disposition of funds. This analysis estimates annual GPC costs as:

$$\textit{Annual GPC Costs} = \$110{,}000$$

Form 9

Air Force Form 9s are used to request larger appropriated funding for purchases such as linens, laundry contract, cleaning supplies, fire-exit signs, carbon-monoxide detectors, office furniture, and paper products. To estimate annual non-GPC appropriated funding, this analysis averages the annual Form 9 totals for FY03 and FY04:

$$Annual\ Form\ 9\ Costs = \$1{,}158{,}942$$

There is no evidence that these costs increase with occupancy or additional facilities. Despite higher on-base occupancy in FY04 and the opening of the new SOC facility in January 2004, FY04 Form 9 funding levels were below FY03 funding levels. This analysis therefore estimates annual Form 9 funding independent of occupancy and new-facility construction.[156]

Total Appropriated-Fund Costs

Combining the annual GPC and Form 9 expenditures, annual appropriated fund totals are estimated as:

$$Total\ Appropriated\ Fund\ Costs = \$1{,}268{,}942$$

Annual appropriated funds are estimated as a fixed cost. It is important to note that the fixed appropriated costs are anchored to the current size of the on-base lodging operation. Increasing on-base occupancy beyond current operational thresholds or the acquisition of new facilities could dictate further annual appropriated-funding requirements. This was not empirically evident in our annual cost data because of the high year-to-year variability and limited historical data. However, the model could be adjusted to reflect marginal increases resulting from increased occupancy or new-facility construction.

5.4.4 Capital Costs

New-facility construction is arguably the most important cost category for analysis of different facility-capacity scenarios. The capital cost of preexisting lodging facilities is not included because those costs are sunk. Constructing and furnishing an additional lodging facility requires an initial investment of roughly $14.6 million. While the majority of the new-facility cost is expensed in the first year, the usefulness of that facility

---

[156] Form 9 funding associated with furnishing a new facility is captured in Section 5.4.4. This section estimates only annual Form 9 funding.

is regained over many years. The up-front capital cost and projected NAF-funded renovation costs should be amortized over the useful life of the facility to convert the cost into a comparable annual expense. Initially, this analysis amortizes the capital costs across 67 years, the Air Force's target recapitilization rate. Alternatively, Section 6.3.3 will analyze a 30-year recapitilization period to evaluate how higher annual amortized costs affect construction recommendations.

A new facility will incur additional renovation costs beyond those accounted for in the NAF amortization and depreciation costs, which include only renovation costs for the preexisting facility stock (Section 5.4.2). Accordingly, renovation costs for newly constructed facilities are included in the capital-cost estimates rather than as add-ons to the amortized NAF-equipment estimates. Future phases of the SOC lodging plan have an annualized real cost of:[157]

Annual Amortized Facility Cost Per Facility = $650,655

5.4.5 Civil-Engineering Costs

In 2001, Maxwell AFB and Gunter Annex outsourced the base operations and support services to DynCorp through a cost-plus contract. DynCorp provides important support to the base lodging operation, functions typically provided by the base civil engineer: utilities and major facility maintenance and repair. The cost estimates separate the lodging portion of these expenditures from the cost of the basewide contract.

Utility Cost

Utility estimates include the annual cost of electricity, natural gas, and water for all lodging facilities. The cost estimates include the effect of new-facility construction, but the available data were not precise enough to capture utility-cost changes related to facility occupancy. Presumably, utility costs would increase with occupancy, but that

[157] Section D.3 in Appendix D describes the methodology for amortizing capital costs over a 67-year life span to convert to an annual expense.

effect could not be estimated from the utility data from the permanent-party dormitories. The annual utility costs are estimated by the function:

$$Utility = \$1{,}036{,}808 + \$61{,}641 * NewSOC\ Facility$$

Facility Maintenance and Repair Cost

Lodging conducts some of the maintenance, repair, and upkeep of its own facilities.[158] However, DynCorp conducts the majority of these activities under contract as the base civil engineer. The annual cost for DynCorp to repair and maintain the lodging facilities is estimated by the function:

$$Maintenance\ and\ Repair = \$2{,}007{,}310 + \$119{,}340 * NewSOC\ Facility$$

DynCorp also performs a small amount of minor construction projects on the lodging facilities at an annual estimated cost of:

$$Minor\ Construction = \$90{,}481$$

Total Civil-Engineering Costs

Combining the three cost estimates, lodging's total civil-engineering costs are:

$$Total\ CE\ Cost = \$3{,}134{,}599 + \$180{,}981 * NewSOC\ Facility$$

5.4.6 Total On-Base Costs

The total of the costs from Subsections 5.4.2 through 5.4.5 is the total annual on-base cost:

$$On\text{-}Base\ Costs = \$10{,}067{,}536 + \$1.9878434 * Occupants + \$850{,}858 * NewSOC\ Facility$$

The vast majority of on-base costs are fixed from year to year. The fixed costs consist of expenses to operate and maintain the current lodging capacity. Incremental

[158] Lodging-performed maintenance costs were captured in the NAF material costs and the NAF-funded renovation grants in Section 5.4.2.

changes in occupancy and new facilities have no affect on the fixed costs and thus are not affected by the simulation. Theoretically, some costs estimated with fixed averages, such as utility costs, civil-engineering maintenance and repair, appropriated Form 9 funding, and NAF material costs, could vary with the number of on-base occupants. However, either the cost data was not specific enough to flush out these effects (civil-engineering costs and appropriated funding) or there was no detectable effect in the data (material costs). Improved data linking executed costs to on-base occupancy and new-facility construction in these areas would enhance this analysis and would generally be of value to Air Force decisionmaking.

The remaining two pieces of the on-base function depend upon the simulation's results for on-base placements and the chosen capacity scenario. Each on-base occupant incurs an additional $1.99 in NAF expenses after the fixed costs of operating the lodging operation at its current capacity have been paid. Each new SOC facility incurs an additional annual expense of $850,858. This cost includes the additional NAF personnel expense of operating a new facility, the amortized capital cost of the new facility and future renovations, and the projected add-on civil-engineering costs for utilities and facility maintenance and repair. AETC's financial managers should review these cost estimates for plausibility and to ensure that no funding categories have been excluded, beyond those discussed in Subsection 5.4.1. Underestimating the marginal components of the on-base cost function will result in tradeoff analyses that recommend too many facilities.

5.5 GENERATING COST DISTRIBUTIONS

The model compiles the *yearly* cost of running the lodging operation from each category in Section 5.4. The analysis compares the expected annual total cost of different facility-capacity scenarios. The off-base cost function in Subsection 5.4.1 and the total on-base cost function in Subsection 5.4.6 are applied to the simulation output and totaled to generate an annual-cost estimate for each simulation run. The model is run hundreds of times for each capacity scenario to account for the stochastic nature of demand and blocked spaces, which change model results for each simulation run. The total costs for

all simulation runs are collected to develop cost distributions, rather than point estimates, for each capacity scenario.

The generated cost distributions provide the basis for evaluating the effect of different capacity scenarios. The cost distributions can be statistically analyzed based on expected costs or cost confidence intervals. The most efficient capacity level for a least-cost objective will be the scenario that minimizes total expected cost.[159] Cost distributions for the other capacity scenarios can also be analyzed for their degree of inefficiency (i.e., how much more it costs to maintain a nonoptimal capacity). A comparison of alternatives, based on Air Force objectives, yields a "best" on-base facility level and an estimate for expected future costs. The efficient on-base facility level is the central policy recommendation; however, Chapter 7 illustrates how the simulation tool can be used to evaluate the effect of lodging management policies on overall lodging cost.

5.6 MODEL VERIFICATION AND VALIDATION

The simulation model was verified and validated to ensure that the algorithm worked correctly. Verification evaluates whether the model works as designed, answering the question, Did you build the model right? Validation, on the other hand, evaluates whether the constructed model reflects reality, or, Did you build the right model?

5.6.1 Verification

The simulation model was verified through a series of independent test cases. Each case altered a key input parameter and assessed whether the model output (i.e., projected contract quarters and on-base occupancy rates) moved in the expected direction. The following test cases were executed:

---

[159] The decisionmaker may want to consider other properties of the cost distribution beyond expected value, such as the variance and the 95 percent confidence bounds.

- Facility capacity was set to include all additional SOC facilities, phases II through VII, for a total of 3,022 on-base rooms, to ensure low contract quarters (if any) and low average occupancy.
- Each facility-capacity scenario was tested to ensure that contract quarters and percent occupancy increased with each incremental reduction in total supply.
- Course-specific placement rules were tested to ensure that attendees were placed in the correct facility in the proper order.
- Blocked spaces were increased, with an expected effect of increasing contract quarters and on-base occupancy rates.
- The mean of the Poisson distribution for TDY stay length was increased and decreased to ensure an increase and a decrease, respectively, of TDY contract quarters. This effect was small because the model-implemented distribution does not perfectly track the Poisson distribution (Figure 5.5).

The test cases generated the expected results, confirming that the model works as designed.

5.6.2 Validation

To validate the model, the simulated results for the FY03 capacity scenario were compared with Maxwell's actual FY03 contract quarters and occupancy rates. Contract quarters in FY03 totaled approximately 69,000, and the on-base occupancy rate was 80.4 percent. The simulation generated an average annual contract-quarters total of 58,541 and an on-base occupancy rate of 79.2 percent. The lower-than-expected occupancy rate does not include the effect of priority-two demand, which is included in the actual rate. When this effect is included, the model's on-base occupancy rate increases to 82.4 percent.

On average, the simulation model is more efficient than the actual FY03 placements. The model predicts fewer personnel in contract quarters and more in on-base quarters, yielding inflated occupancy rates. This occurs for a number of reasons, each of which has been discussed in this chapter:

- The generated stay lengths for residual demanders are skewed toward shorter stays. Approximately 50 percent of residual demanders stay for only one day. As a result, the residual-demand model more closely approximates the single-period excess-demand case that does not include more-rigid multiday stays and underestimates contract quarters (see footnote 127).
- The model includes the effect of blocked spaces on supply before it runs. Consequently, the simulation works around preplanned blockages when it places demands and does not dynamically react to blockages in the same way lodging does in reality (see p. 85). The model could be extended to include dynamic blocked spaces, but the added benefit is small relative to the added complexity.
- Blocked spaces are subtracted from each facility's total space, which means that the same rooms in each facility are always blocked first. As in the real world, randomly occurring blockages would be more disruptive to the reservation placement system (see footnote 132). This is another area for potential model improvement.
- The simulation places all course demands before placing any residual demands. In reality, TDY reservations can be made at any time, and they are not bumped by course demands. The presence of already-reserved rooms would lower the efficiency of the course-placement process (see footnote 135). Additional data on the timing of TDY reservations would be needed to eliminate this small potential source of error.
- The simulation's placement algorithm makes the most efficient on-base placement for each demander. If no rooms are available for the entire stay length, the algorithm checks on-base and off-base combinations, starting with the combinations that minimize off-base time (i.e., five days off-base and the rest on-base). The model checks all on-base/off-base combinations before placing the demand off-base for the entire stay length. While this is the objective of Maxwell's reservation system, the simulation is probably more efficient than reality because it can evaluate thousands of placement options in

very little time, whereas this task is performed manually in the current reservation system (see p. 87).

- The simulation places each day's residual demands in order, from longest to shortest stay duration. This is the most efficient way to place the residual demands because it utilizes the longest room availabilities for the longest requirements. In reality, residual-demand reservations occur more randomly, according to when the individual reservations are placed (see p. 87). More-detailed data on the individual TDY demanders would be required to eliminate this source of error.

Ideally, the model's performance would exactly replicate the reality of the lodging operation, making model results directly applicable. Model validation reveals that the simulation's assumptions make it more efficient than the actual reservation system, yielding a consistent model bias that underestimates contract quarters and overestimates on-base efficiency. Therefore, the model's results should be interpreted as lower bounds for the number of project contract quarters and upper bounds for on-base efficiency. The analysis of the model's results should qualitatively consider the modeling bias or adjust model results according to the method described in Section 6.2 to avoid a bias that would result in construction of too few facilities.[160] The decisionmaker could qualitatively adjust his decision in favor of more facility construction, especially if the cost difference between alternative capacity scenarios is small.

Despite the underestimate, the simulation improves on the excess-demand projections of Chapter 3. Table 5.3 revisits Table 3.3, which compares excess-demand projections to actual contract quarters and includes the simulation model's annual-contract-quarters estimates. While still an imperfect predictor, the simulation model provides an 85 percent solution. In addition, qualitatively weighting the simulation's

---

[160] This is similar to, albeit smaller than, the consistent bias of using excess-demand measures to project contract quarters that was shown in Chapter 3.

results would be easier than weighting the excess-demand measures, because it would involve a lower weighting factor.

Table 5.3
Comparison of Actual Contract Quarters with Modeling Estimates

	FY03
Contract-quarters projections from monthly average	
Demand – total space (Figure 3.1)	4,184
Contract-quarters projections from daily-demand data	
Demand – total space (Figure 3.2)	22,446
Demand – available-space projections (Figure 3.3)	28,498
Simulation model	58,541
Actual contract quarters	~ 69, 000

5.7 SUMMARY

This chapter has discussed the implementation of the inventory simulation model presented in Chapter 4. Sections 5.1 through 5.5 covered each major component of the model: (1) estimating demand, (2) determining supply, (3) generating on-base and off-base facility placements, (4) estimating lodging's total cost function, and (5) calculating total cost distributions from the simulation output. Section 5.6 described the verification and validation of the model, justifying its use for determining efficient capacity at Maxwell. Chapter 6 evaluates the model results to determine an efficient on-base facility capacity.

6. EFFICIENT FACILITY CAPACITY

This chapter analyzes the simulation's results to determine the efficient number of on-base lodging rooms at Maxwell AFB. Each scenario's expected total lodging costs, along with a cost confidence interval, are compared to select the least-cost provision of lodging. Results are evaluated to ensure that the model's underestimate of annual contract quarters does not result in a recommended facility capacity that is too low. Construction recommendations can be qualitatively weighted in favor of additional construction when significant contract-quarters costs are being excluded and the incremental cost difference for one additional facility is small. Finally, the recommendations are tested for robustness against the FY04 course schedule and varying contract-quarters prices to ensure that they are not relevant only to the lodging system in FY03.

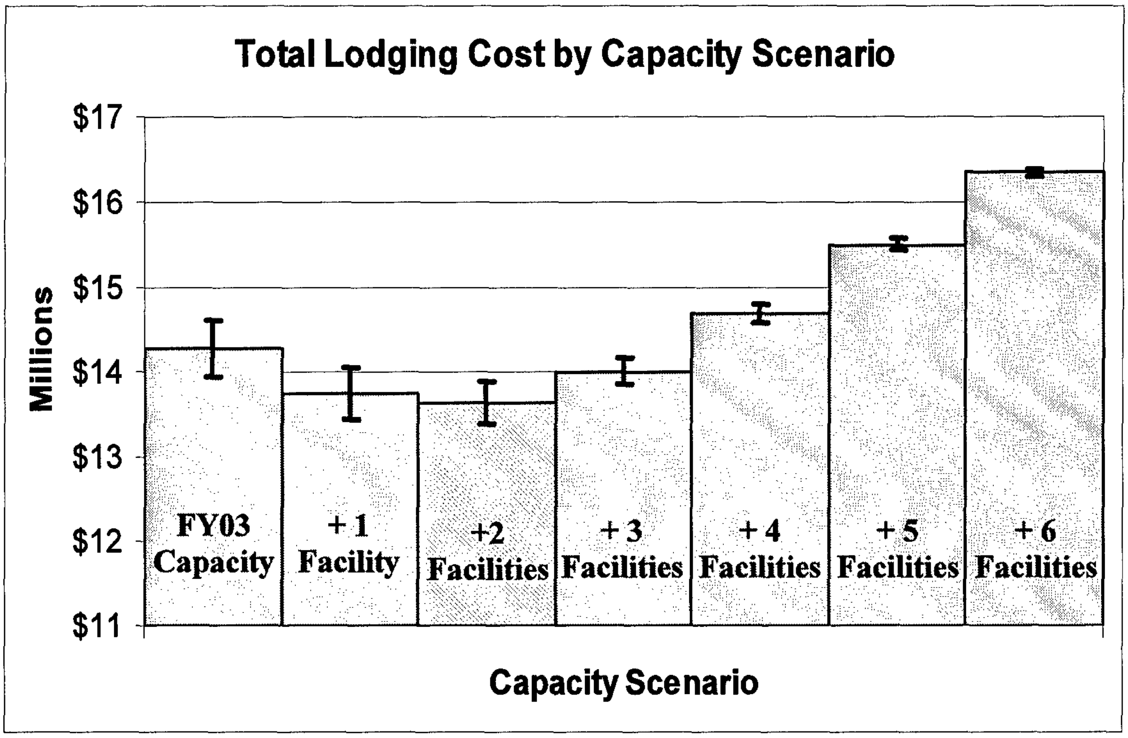
6.1 MODEL RESULTS

Figure 6.1 shows the simulation's average annual-cost estimates for each capacity scenario.[161] It also includes a two-standard-deviation confidence bound for each estimate, based on the variation of the individual results of each scenario's model runs. A two-standard-deviation confidence bound approximates the 95 percent confidence interval for total cost.[162] The standard deviation decreases with additional facilities because the added capacity makes the results less sensitive to the stochastic parameters of the model, i.e., residual demand and blocked spaces.

---

[161] The capacity scenarios are based on the phased construction of the SOC lodging plan in Table 2.2.

[162] A two-standard-deviation confidence interval includes approximately 95 percent of the cases when the data are normally distributed. The simulation results for each scenario are not precisely normally distributed but are close. Therefore, the two-standard-deviation confidence bound is roughly equivalent to the 95 percent confidence bound. For the tested capacity scenarios, the confidence bounds contain between 90 and 98 percent of the simulated results.



NOTES: The Y-axis scale is not normalized to zero to display confidence intervals. The +1 facility scenario is completion of phase II of the SOC lodging plan, the +2 scenario is phase III, etc.

Figure 6.1 – Total-Cost Estimates by Capacity Scenario for FY03 Demand

The least-cost capacity for meeting FY03 demand would have required an additional two SOC lodging facilities. This capacity balances the additional facility costs against the cost savings from lower contract-quarters requirements. Interestingly, the least-cost solution results in an annual priority-one occupancy rate of only 73 percent, rising to roughly 76percent after including priority-two demands.[163] This occupancy rate is significantly below the Air Force's target, 85 percent occupancy. If the 85 percent metric is used, it would dictate even fewer facilities than the FY03 scenario does, which would cost the Air Force at least a half-million dollars annually. Expanding on Figure

[163] FY03 priority-two demands totaled approximately 23,000, which would increase on-base occupancy by 3 percent.

6.1, Table 6.1 presents the annual-cost estimates, separated into on-base and off-base expenditures, and the on-base occupancy rates for each capacity scenario.

Table 6.1
Model Results: Annual Costs and Occupancy Rates

Model Results	FY03	+ 1 Facility	+ 2 Facilities	+ 3 Facilities	+ 4 Facilities
Contract-quarters cost ($ thousands)	3,161	1,733	729	230	60
On-base lodging cost ($ thousands)	11,121	12,025	12,912	13,781	14,638
Total-cost average ($ thousands)	**14,282**	**13,757**	**13,641**	**14,011**	**14,698**
2 SD lower bound	13,941	13,457	13,403	13,847	14,595
2 SD upper bound	14,623	14,058	13,880	14,175	14,802
On-base occupancy (%)					
Without priority-two	79.2	76.4	73.0	69.0	64.8
With priority-two	82.4	79.5	75.9	71.7	67.3

NOTES: The last two capacity scenarios (+ 5 and + 6 facilities) are excluded from the table for ease of presentation. Total-cost estimates are rising over this range. The confidence bounds are two standard deviations above and below the mean, which is roughly equivalent to the 95 percent confidence interval for total cost.

Simply stated, additional facility construction is justified when the annual off-base cost savings exceed the additional annual on-base construction and operating costs (Table 6.2). For example, the first and second new facilities are justified because the contract-quarters savings are greater than the marginal increase in on-base costs. Table 6.2 shows why construction beyond two additional facilities would increase total lodging costs. Construction beyond two additional facilities would increase on-base costs faster than contract-quarters cost would decrease. As a general guideline, each additional facility

costs between $850,000 and $900,000 per year.[164] To justify additional facility construction, the projected contract-quarters cost savings of an additional facility must exceed $900,000. It is important that the estimates for cost savings from reduced contract-quarters dependency be made using a tool like the simulation model to properly account for the contract quarters that would actually be saved through new-facility construction.[165]

Table 6.2
Incremental Savings and Costs, by Facility-Construction Scenario

Annual Cost Estimates	FY03	+1 Facility	+2 Facilities	+3 Facilities	+4 Facilities
Contract-quarters cost savings, by facility ($ thousands)	-	1,428	1,004	499	170
On-base lodging cost increase, by facility ($ thousands)	-	904	888	869	857

These results and recommendations are based on the simulated reservation placements for each capacity scenario and the estimated cost functions. As described in Section 5.6.2, the model has a small downward bias on its contract-quarters estimates. In general, a methodology that overstates the efficiency of on-base quarters risks understating the efficient facility capacity. Section 6.2 provides a methodology to correct the bias and evaluates whether the facility-construction recommendations in this section are consistent, despite the bias.

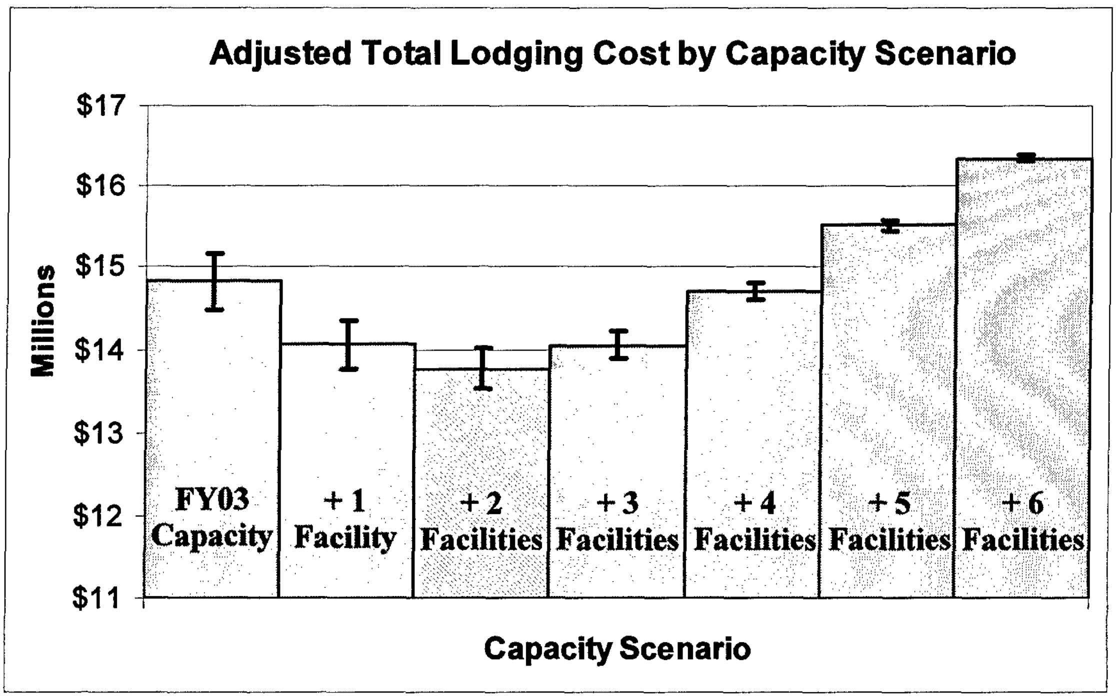
---

164 This estimate includes the amortized construction cost and all incremental costs of operating and maintaining an additional facility. The majority of the cost (~$650,000) is the amortized cost of construction, furnishing, and future renovations. The deviation in cost increases by facility results from decreasing incremental on-base occupancy increases (and therefore lower incremental operating-cost increases) with each additional facility.

165 Cost avoidance estimates from excess-demand measures would overstate the effectiveness of a new facility in reducing contract quarters. For example, an additional 152-room facility will not save 152 contract quarters on all days that have at least 152 contract quarters. On-base placement and movement restrictions still apply and would need to be modeled.

6.2 QUALITATIVELY ADJUSTING MODEL RESULTS FOR CONTRACT-QUARTERS UNDERESTIMATES

Table 5.4 showed that, on average, we are able to account for roughly 58,500 of the approximately 69,000 actual contract quarters in FY03. In Chapter 5, we discussed the reasons for this understatement and suggested that adjustments can be made to the model results to ensure that they do not understate the efficient capacity. This section adjusts the results from Table 6.1 to reflect the higher number of contract quarters and decreased utilization of on-base facilities. Figure 6.2 presents these adjusted results. The methodology for making this adjustment is discussed in Appendix E.



NOTE: The Y-axis scale is not normalized to zero to display confidence intervals. The +1 facility scenario is completion of phase II of the SOC lodging plan, the +2 scenario is phase III, etc.

Figure 6.2 – Adjusted Total-Cost Estimates, by Capacity Scenario

Although the adjustment makes additional construction (+3 facilities) relatively more attractive, the efficient capacity does not change. The least-cost capacity remains an additional two SOC lodging facilities over FY03 capacity levels. The first two capacity scenarios become less desirable because of higher contract-quarters cost, but this effect phases out in the later capacity scenarios due to their lower contract-quarters totals. Expanding on Figure 6.2, Table 6.3 presents the adjusted cost estimates, separated into on-base and off-base expenditures, and the on-base occupancy rates for each capacity scenario. In each scenario, total costs increase because of higher contract-quarters utilization, while on-base occupancy rates and costs decrease because of reductions in the number of personnel lodged on-base.

Table 6.3
Adjusted Model Results: Annual Costs and Occupancy

Model Results	FY03	+ 1 Facility	+ 2 Facilities	+ 3 Facilities	+ 4 Facilities
Contract-quarters cost ($ thousands)	3,726	2,042	859	271	71
On-base lodging cost ($ thousands)	11,100	12,013	12,908	13,780	14,638
Total-cost average ($ thousands)	**14,826**	**14,056**	**13,767**	**14,051**	**14,708**
2 SD lower bound	14,485	13,755	13,528	13,887	14,605
2 SD upper bound	15,167	14,356	14,005	14,214	14,812
On-base occupancy (%)					
Without priority-two	77.6	75.6	72.7	68.9	64.8
With priority-two	80.9	78.8	75.6	71.6	67.3

NOTES: The last two capacity scenarios (+ 5 and + 6 facilities) are excluded from the table for ease of presentation. Total cost estimates are rising over this range. The confidence bounds are two standard deviations above and below the mean, which is roughly equivalent to the 95 percent confidence interval for total cost.

Comparing Table 6.3 with the results from Section 6.1, total-cost estimates for the FY03 capacity scenario increased \$544,000 due to higher contract-quarters costs. Likewise, total-cost estimates for phase II (+ 1 facility) increased nearly \$300,000. After the first two capacity scenarios, however, the total cost increases are small. The phase III (+ 2 facilities) estimate is approximately \$125,000 higher, phase IV (+ 3 facilities) is only \$40,000 higher, and phase V (+ 4 facilities) is only \$10,000 higher. With respect to total costs, these are small differences, which explains why the adjustment does not dictate additional construction.

Table 6.4 displays the marginal contract-cost savings and on-base cost increases for each capacity addition. While constructing three facilities became relatively more attractive in comparison with the results in Section 6.1, the additional \$872,000 on-base operating costs are not offset by the \$588,000 savings in contract-quarters costs. Therefore, constructing two additional facilities still minimizes total lodging costs.

Table 6.4
Adjusted Incremental Savings and Costs, by Facility-Construction Scenario

Annual Cost Estimates	FY03	+ 1 Facility	+ 2 Facilities	+ 3 Facilities	+ 4 Facilities
Contract-quarters cost savings, by facility (\$ thousands)	—	1,684	1,183	588	200
On-base lodging cost increase, by facility (\$ thousands)	—	913	894	872	858

This example suggests that the contract-quarters underestimate in this analysis is not a significant factor in capacity determination. As the number of contract quarters decreases in each capacity scenario, the underestimate and thus the modeling bias decreases as well.[166] Therefore, the total-cost estimates will be close to reality unless a scenario's total contract quarters are high (>25,000), which for FY03 demand occurred

166 This conclusion is based on the reasonable assumption that the model's uncaptured contract quarters decrease at the same rate as the overall contract-quarters totals between capacity scenarios.

only in the first two capacity scenarios.[167] Also, the understated costs will affect construction recommendations only if the differences in total costs between the recommended scenario and alternative capacity scenarios are small. If either of these conditions is not met, the facility recommendations will not be affected by the model's underestimate of contract quarters.

6.3 SENSITIVITY ANALYSIS

Sensitivity analysis is conducted to test the robustness of policy recommendations to varying input values. It is important to remember that the facility recommendations in Sections 6.1 and 6.2 are contingent upon the FY03 demand distribution and the estimated cost functions in Section 5.4. Because deviations from these estimates could affect construction recommendations, it is important to evaluate the sensitivity of the results to variable input parameters. This section evaluates results against a different demand scenario, fluctuations in the contract-quarters price, and a shorter recapitalization period.

6.3.1 Annual Demand Profile

Historical demand trends reveal that there is significant variation in year-to-year demand levels (Figure 6.3). The growth of Maxwell's training programs since FY00 did not slow in FY04, challenging the assumption that FY03 demand is representative of future annual-demand profiles. In addition to aggregate demand changes, course changes affecting length, the number of offerings per year, and course overlaps change the demand composition, thereby affecting lodging placements.[168] Testing policy

[167] Annual contract-quarters totals of 25,000 will lead to an approximate total-cost underestimate of $200,000. This assumes that the model underestimates roughly 15 percent of total annual contract quarters at $54 apiece. For example, 15 percent of 25,000 contract quarters equals 3,750 contract quarters. At $54 apiece, this results in a total-cost underestimate of approximately $200,000.

[168] The changes to the Air and Space Basic Course (ASBC) for FY04 are a good example. The course was lengthened (from four weeks to six weeks), the number of students in each class was increased (from 640 to 840), and a joint curriculum was created with the SNCO Academy, requiring scheduling overlap between the two courses.

recommendations against different demand scenarios is important to ensure that the efficient facility levels are not narrowly tailored to the situation in FY03.

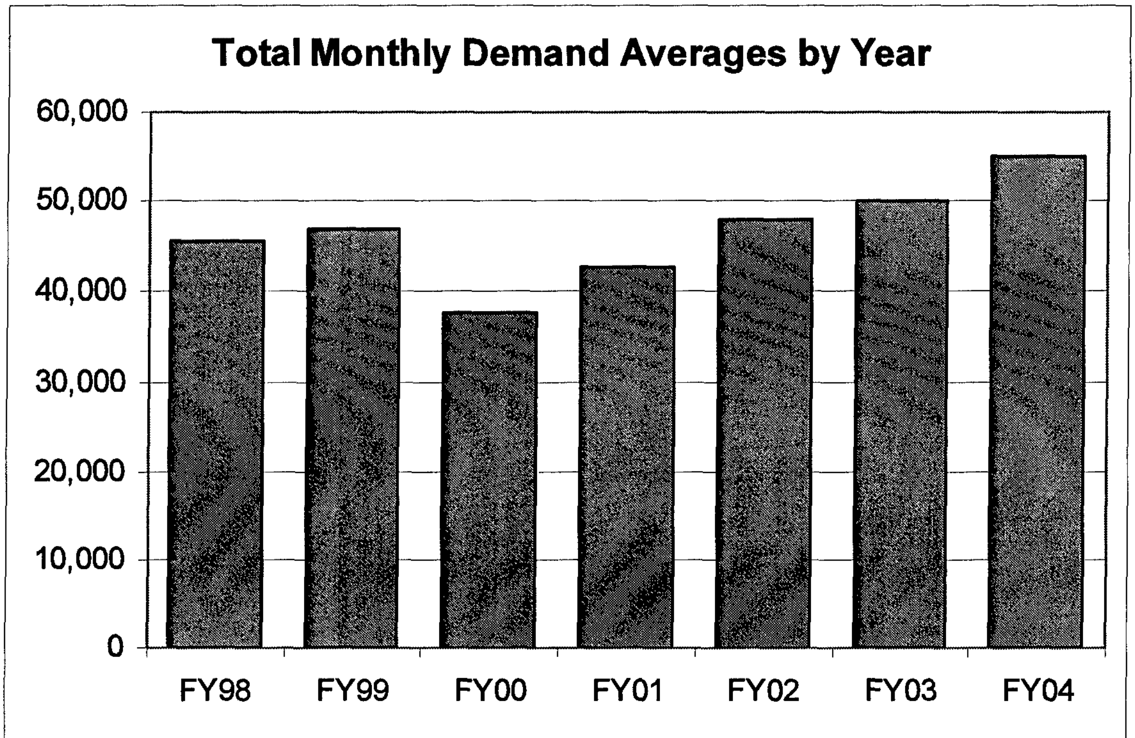


Figure 6.3 – Average Monthly Demand at Maxwell and Gunter, by Fiscal Year

If construction recommendations change between demand scenarios, decisionmakers must determine what they believe to be the more likely future annual-demand profile and must evaluate their preferred construction decision against other-than-expected demand scenarios.[169] Since facility construction requires a substantial initial capital investment that has a lengthy payback period, the simulation should not be used to determine the optimal facility capacity for a temporary demand increase. The methodology is, however, flexible enough to evaluate an annual-demand profile selected by the decisionmaker as representative, based on future projections or historical data.

---

[169] For example, a decisionmaker may decide to construct one less facility than the efficient capacity target to reduce the financial risk of overbuilding should annual demand decrease in the future.

The FY04 analysis requires only minor adjustments to the FY03 model to generalize the tool for use in any fiscal year. The largest change is that the FY04 course schedules replace the FY03 schedules. Changes to the course schedules account for the demand increase between years (course demands increased from 519,000 in FY03 to 595,000 in FY04). The FY04 residual demands (~60,000 annual bed spaces) are predicted using the FY03 predictive model with a small modification to generalize the model to predict demands in any year.[170] Appendix C describes the changes to the model and the reason for the change (see Section C.2).

The blocked-spaces model also had to be changed to generalize the model to FY04. Without the daily data on FY04 blocked spaces, we assumed that FY04 blockages will mirror those in FY03, for which we have data.[171] The number of blocked spaces from the FY03 data is carried over to FY04, but the timing of the blockages is not. The random blocked spaces should be consistent from year to year and are stochastically modeled in the same way. However, the deterministic blocked spaces were adjusted in the FY04 model to occur during the low-course-demand periods in FY04.[172] Most deterministic blocked spaces were rescheduled to low-demand days in FY04, but some were eliminated because there were no nearby low-demand periods available for rescheduling. As a result, the aggregate number of blocked spaces in the FY04 model decreased 17 percent from FY03 totals. Underestimating the number of blocked spaces could lead to overstating the efficiency of the on-base facilities, but that is unlikely, since the excluded scheduled blocked spaces would have occurred during low-demand periods and would

---

[170] FY04 residual demands are predicted from the FY03 data because we did not have access to daily occupancy rates for FY04. This is a fine assumption, because the residual-demand categories (i.e., other TDYs or courses not registered in EMS) should be approximately the same between years. Once daily data are exportable from LTS, further research should be done on predicting residual demands from several years of data.

[171] Once daily data are exportable from LTS, further research should be done in modeling the year-to-year blocked spaces, rather than relying on FY03 data.

[172] Some blocked spaces were modeled deterministically because large renovations are purposefully scheduled during low-demand periods to minimize the effect on occupancy. While there was a heavy overlap (i.e., over the Christmas holiday), low-demand days in FY03 did not directly correspond to the low-demand days in FY04. The blocked spaces scheduled during these periods in FY03 would not occur at the same time in FY04 if course demands were higher on these days. Consequently, the deterministic blocked-spaces model was adjusted to schedule the major facility renovations on low-demand days in FY04.

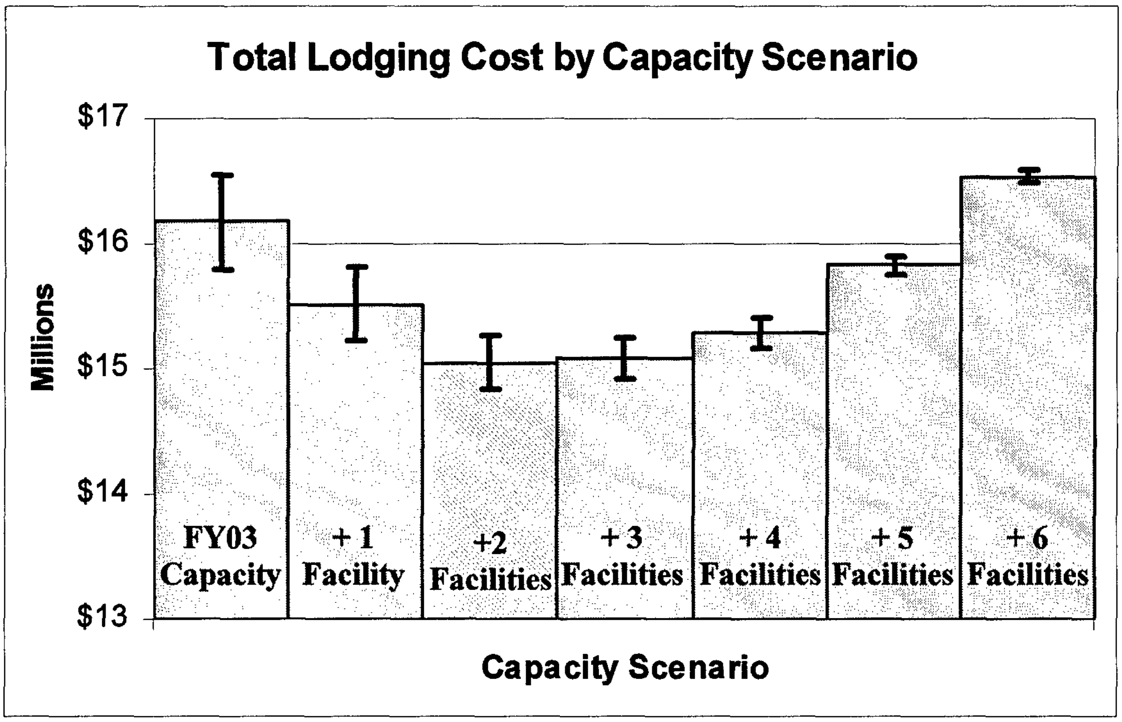
have little effect on inducing more off-base placements. Despite these assumptions and imperfections, the FY04 model results tracked well with the actual FY04 contract-quarters totals through June.[173] This helps validate the model and gives us confidence that it reflects the reality in FY04. The primary effect of the lower number of blocked spaces is an underestimate of the on-base occupancy rates by 2 percent because more blocked space reduces the overall available space.[174]

Figure 6.4 shows the average annual-cost estimates with FY04 demand for each capacity scenario. The figure also includes the two-standard-deviation confidence bound for each estimate. Again, the standard deviation decreases with additional facilities because the added capacity makes the results less sensitive to the stochastic parameters of the model, i.e., residual demand and blocked spaces.

---

[173] The number of actual contract quarters was approximately 54,000 through June, for an estimated annual total of 72,000. This compares well to the FY04 model's predicted annual totals of 63,500 for the +1 facility scenario and 92,500 for FY03-capacity scenario. Since the new facility (phase II) actually opened in January, making it available for three-quarters of the year, we would expect the actual FY04 contract quarters to be between the model's predictions for these two capacity scenarios and closer to the +1 facilityscenario, which they are.

[174] This calculation is based on understating the average number of blocked spaces by 38 per day, which would total 13,870 annually. Depending on the capacity scenario, this would represent 2 percent or less of the total number of spaces. This understatement is in relation to FY03 blocked-space totals, which may be different in FY04.



NOTES: The Y-axis scale is not normalized to zero to display confidence intervals. The +1 facility scenario is completion of phase II of the SOC lodging plan, the +2 scenario is phase III, etc.

Figure 6.4 – FY04-Demand Total-Cost Estimates, by Capacity Scenario

Despite the higher aggregate demand in FY04, the least-cost capacity is the same as that for FY03 demand, i.e., two additional SOC lodging facilities. Interestingly, constructing three additional lodging facilities becomes relatively more attractive because the increased demand leads to higher contract quarters at the lower capacities and more cost savings through additional construction. Expanding on Figure 6.4, Table 6.5 presents the annual-cost estimates, separated into on-base and off-base expenditures, and the on-base occupancy rates for each capacity scenario.

Table 6.5
FY04 Demand Model Results: Annual Costs and Occupancy

Model Results	FY03	+ 1 Facility	+ 2 Facilities	+ 3 Facilities	+ 4 Facilities	+5 Facilities
Contract-quarters cost ($ thousands)	4,995	3,427	2,057	1,208	529	216
On-base lodging cost ($ thousands)	11,182	12,092	12,993	13,876	14,750	15,614
Total-cost average ($ thousands)	**16,177**	**15,520**	**15,051**	**15,084**	**15,279**	**15,830**
2 SD lower bound	15,802	15,229	14,833	14,923	15,156	15,753
2 SD upper bound	16,551	15,811	15,268	15,245	15,402	15,908
On-base occupancy (%)						
Without priority-two	82.2	79.7	76.9	73.5	70.0	66.5
With priority-two	85.5	82.8	79.8	76.1	72.5	68.8

NOTES: The last capacity scenario (+ 6 facilities) is excluded from the table for ease of presentation. Total cost estimates are rising over this range. The confidence bounds are two standard deviations above and below the mean, which is roughly equivalent to the 95 percent confidence interval for total cost.

Similar to the results in Section 6.1, the least-cost capacity yields an annual-occupancy rate below the Air Force target of 85 percent. The two low-cost capacity scenarios, +2 facilities and +3 facilities, yield annual-occupancy rates of 77 and 74 percent for priority-one demands only and 80 and 76 percent when priority-two demands are included.[175] The average cost difference between constructing two or three facilities is only $33,000. The contract-quarters savings from building the third facility is almost exactly offset by the additional cost of construction and operation (Table 6.6).

---

[175] Priority-two demands were added at FY03 levels of approximately 23,000, which would increase on-base occupancy by approximately 3 percent.

Table 6.6
FY04 Demand Incremental Savings and Costs, by Facility-Construction Scenario

Annual cost estimates	+ 1 Facility	+ 2 Facilities	+ 3 Facilities	+ 4 Facilities	+ 5 Facilities
Contract-quarters cost savings, by facility ($ thousands)	1,567	1,370	849	679	313
On-base lodging cost increase, by facility ($ thousands)	910	901	882	874	864

Since costs are nearly equivalent, additional criteria could be employed to choose between these two scenarios. For example, if a decisionmaker preferred to lodge personnel on-base rather than off-base to reduce transportation costs and inconvenience, constructing three facilities would achieve those objectives for only a small increase in cost.[176] Conversely, if the decisionmaker were uncertain that heightened FY04 demand levels would persist into the future, constructing only two facilities would hedge the risk of overbuilding to a demand peak—in the FY03 demand case, annual costs were $370,000 more for three facilities than for two (Table 6.1).

In determining the least-cost capacity, Air Force decisionmakers must determine what they believe represents a future annual-demand profile and evaluate their construction decision against other-than-expected demand scenarios. Since facility construction requires a substantial initial capital investment with a lengthy payback period, construction should not be undertaken for a temporary demand increase.[177] If FY04 aggregate demand levels will continue into the foreseeable future—or even

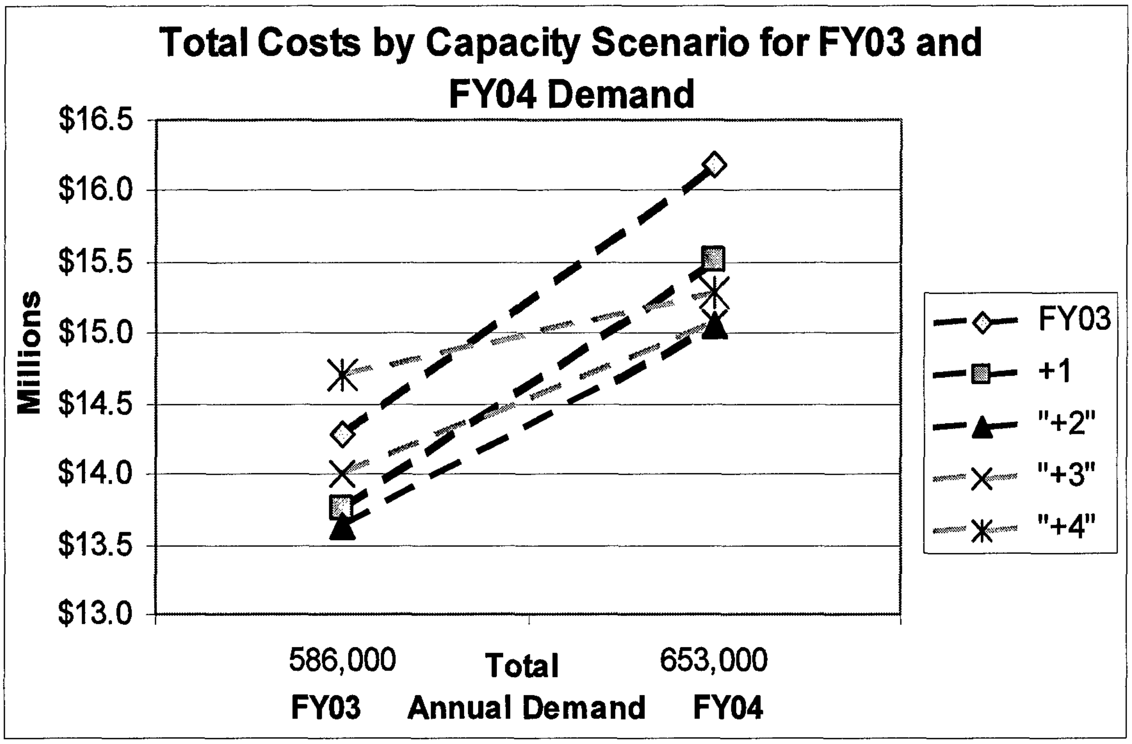
---

[176] It is important to remember that the costs in this analysis do not include differing on-base/off-base per diem rates, transportation costs or other nonmonetary costs associated with sending personnel off-base. The model's cost figures include only the costs outlined in Chapter 5.

[177] The present value of each facility is amortized over the 67-year facility life span. However, the facility cost is recouped more quickly in the initial years due to real interest-rate discounting (see Figure D.15 in Appendix D). For example, three-quarters of the present value of a building is paid for after 33 years.

increase, as they have done over the past several fiscal years—constructing three additional SOC facilities may be justified to place more personnel on-base and avoid the risk of higher contract-quarters costs. However, if decisionmakers believe FY03 demand levels are more representative of future annual demands, constructing only two additional facilities will minimize total lodging costs.

Figure 6.5 shows the total-cost estimates for each capacity in both demand scenarios. Figure 6.5, like Figures 6.1 and 6.4 and Tables 6.1 and 6.5, can be used to evaluate the degree of inefficiency (i.e., excess cost) that would result from a choice to overbuild or underbuild. For example, if a decisionmaker chooses to construct three facilities because he believes annual demand will remain at FY04 levels and possibly increase but demand then decreases back to FY03 levels, the additional expense will be approximately $370,000 per year because of the extra operating and amortized capital costs. This figure allows the decisionmaker to perform a risk assessment based on construction options and assessed probabilities of different demand futures.



NOTES: The X-axis and Y-axis scales are not normalized to zero to show detail. The +1 facility scenario is completion of phase II of the SOC lodging plan, the +2 scenario is phase III, etc.

Figure 6.5 – Total Costs, by Capacity Scenario, for FY03 and FY04 Demand

Figure 6.5 compares only the average cost estimates in the two demand scenarios. The dashed lines connecting the points are not estimates for the costs at all demand levels between the aggregate totals for FY03 and FY04. Costs for each capacity are not expected to increase linearly with demand. Costs increase with demand for two reasons: (1) higher on-base occupancy drives up on-base operating costs, and (2) an increased contract-quarters requirement drives up total contract costs. The rate at which costs increase depends on the proportion of extra demanders being placed on-base versus off-base. If demand increases can be absorbed within the slack capacity of current on-base facilities, costs will increase at the much lower on-base marginal cost of approximately $2 per occupant (Section 5.4.2). However, if demand increases and fixed capacity drive a higher contract-quarters requirement, the marginal cost for individuals placed off-base

is the contract-quarters price of $54. This explains the different-sloped lines in Figure 6.5. The lower capacities (FY03 and +1 facility) have less excess capacity to absorb the increased FY04 demand, resulting in an increased contract-quarters requirement and therefore a higher marginal cost (slope). The larger capacities (+3 and +4 facilities) have more on-base space to absorb the increased demand and thereby incur lower marginal costs.

It is important that a tool such as our simulation be used to predict the proportion of demanders placed on-base at each demand level. Considerations that span days, such as length of stay and movement restrictions, determine new demanders' lodging placements. Thus, the dashed lines connecting the two points logically do not estimate the cost at each demand level. More likely, the costs between and beyond the point estimates would be best estimated by a nonlinear function, because as demands increase for a set capacity, the proportion of new demanders placed off-base will also increase. This proportion increases with demand because on-base availability will continue to decrease as some of the new demanders are placed in available on-base quarters.

The ability to better estimate these cost functions at any demand level is a rich area for future work. The present analysis provides the cost estimates for each capacity scenario at two relevant demand levels (FY03 and FY04 demands) and allows the decisionmaker to perform a risk assessment based on projected future-demand profiles.

6.3.2 Sensitivity to Contract-Quarters Price

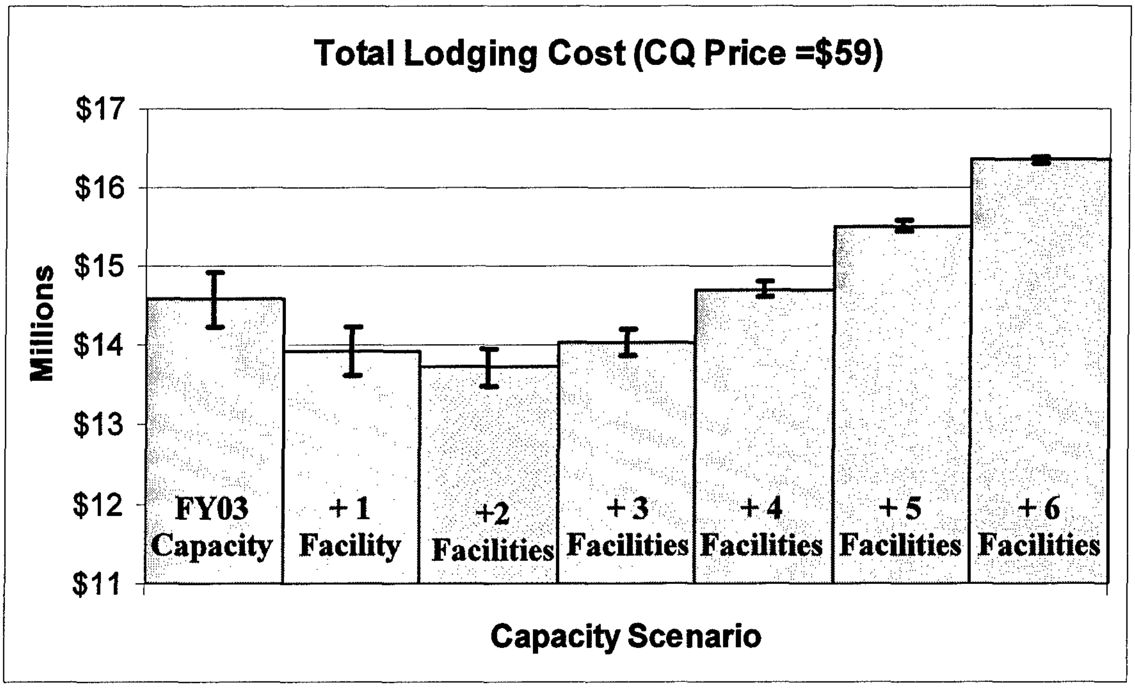
Up to this point, results have been dependent upon the cost functions derived in Section 5.4. Variations in these cost functions could change the facility recommendations as on-base or off-base quarters became relatively more expensive. This subsection evaluates a scenario where the price of contract quarters increases (the more likely scenario) or decreases. The base has contracts with local hotels to provide accommodations at below-market rates ranging from $45 to $57 per night. The average FY03 contract-quarters price was $54. Generally, as the price of contract quarters increases, it becomes more desirable to lodge personnel on-base. Conversely, a decrease in the price of off-base quarters makes utilizing them relatively more attractive.

Price Increase

A higher contract-quarters price could lead to a recommendation of additional construction beyond the level recommended earlier in this chapter. This section analyzes the effect of a $5-per-room increase, a plausible increase that yields an average contract-quarters price of $59. Figure 6.6 presents the total-cost estimates for FY03 demand and the higher contract-quarters price. As expected, the scenarios with the most contract quarters (at the left in Figure 6.6) experience higher total costs, whereas scenarios with a low reliance on contract quarters (at the right) are less affected by the price change. Most important, the recommendation to construct two additional facilities (phases II and III) is unchanged as the least-cost option. The construction recommendation is not affected by an increased contract-quarters price. In fact, off-base prices would have to increase to $95 per room before the cost of constructing two facilities would rise enough to equal the total costs of constructing three facilities.[178]

---

[178] This calculation is based on the model results from Section 6.1. The annual cost of constructing three facilities was $370,000 greater than that of constructing two facilities.



NOTES: Y-axis scale is not normalized to zero to display confidence intervals. The +1 facility scenario is completion of phase II of the SOC lodging plan, the +2 scenario is phase III, etc.

Figure 6.6 – Total-Cost Estimates, by Capacity Scenario, for FY03 Demand and a Contract-Quarters Price of $59 per Night

Expanding on Figure 6.6, Table 6.7 presents the annual-cost estimates, separated into on-base and off-base expenditures. The on-base occupancy rates for each capacity scenario are excluded, because they are unchanged from Table 6.1, since only the contract-quarters price has been changed.

Table 6.7
Annual Costs for FY03 Demand with $59 Contract Quarters

Model Results	FY03	+ 1 Facility	+ 2 Facilities	+ 3 Facilities	+ 4 Facilities	+5 Facilities
Contract-quarters cost ($ thousands)	3,454	1,893	796	251	66	21
On-base lodging cost ($ thousands)	11,121	12,025	12,912	13,781	14,638	15,491
Total-cost average ($ thousands)	**14,575**	**13,918**	**13,709**	**$14,032**	**14,704**	**15,512**
2 SD lower bound	14,203	13,590	13,448	13,854	14,591	15,446
2 SD upper bound	14,947	14,245	13,969	14,211	14,817	15,578

NOTES: The last capacity scenario (+ 6 facilities) is excluded from the table for ease of presentation. Total cost estimates are rising over this range. The confidence bounds are two standard deviations above and below the mean, which is roughly equivalent to the 95 percent confidence interval for total cost.

A contract-quarters price increase makes additional construction relatively more desirable and the low-capacity scenarios with higher contract quarters much less desirable. Generally, a price change will not affect the recommended least-cost facility capacity unless the change is large and the cost differences between the efficient capacity and alternative scenarios is small. In this example, a $5 increase decreased the cost gap between constructing a third facility from $370,000 to $323,000 but did not change the recommended capacity.

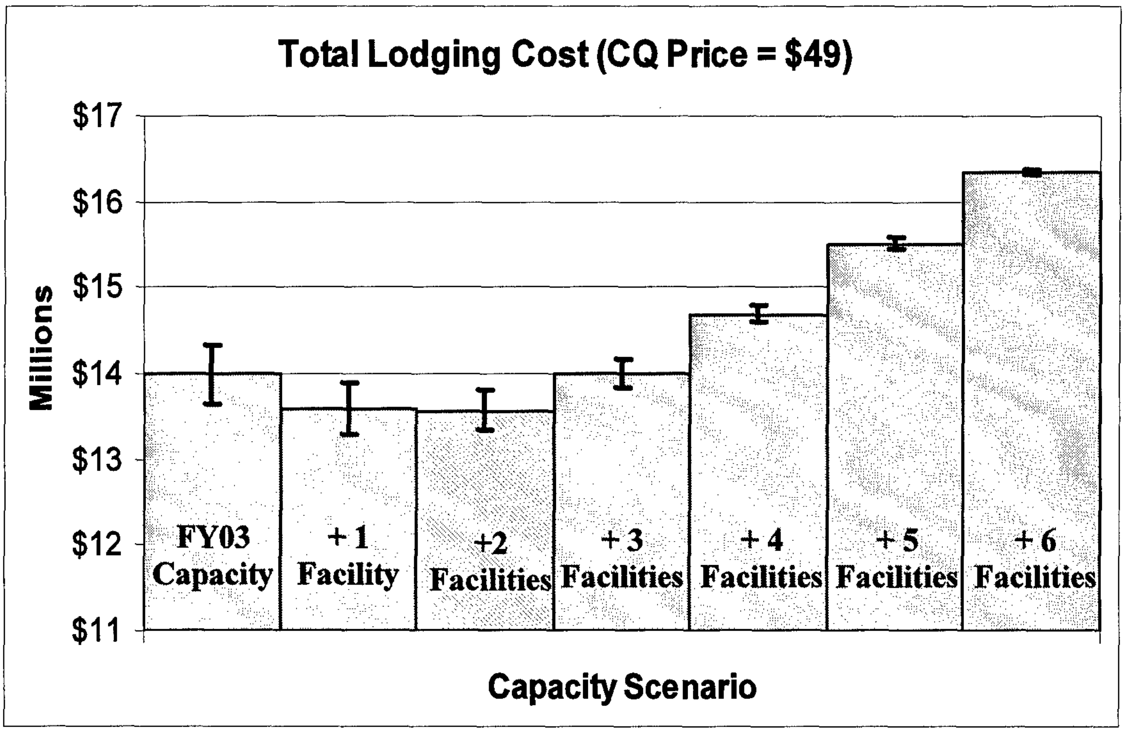
Price Decrease

Conversely, a decrease in contract-quarters prices makes off-base quarters relatively less costly and therefore more advantageous to utilize. At some point, a lower unit cost will decrease the recommended on-base capacity. This section analyzes the effect of a $5-per-room decrease, which yields an average contract-quarters price of $49. Historically, a price decrease has been less likely than an increase, but we investigate the effect nonetheless. Figure 6.7 presents the total-cost estimates for each capacity scenario with the lower contract-quarters price. As expected, the scenarios with the most contract

quarters (at the left in the figure) become relatively less expensive, whereas those with low reliance on contract quarters (at right) are less affected by the price change. Most important, the least-cost capacity recommendation, i.e., construct two additional facilities (phases II and III), is unchanged. However, there is now almost no cost difference between constructing one or two facilities. If prices dropped further to $47 per contract room, the cost of constructing two facilities would exceed that of constructing only one facility.[179]

---

[179] This calculation is based on the model results from Section 6.1. Constructing one facility was $116,000 more expensive than constructing two facilities because of the higher contract-quarters expenses with only one facility. If contract-quarters prices dropped to $47, the cost difference between the two capacity scenarios would be negligible.



NOTES: The Y-axis scale is not normalized to zero to display confidence intervals. The +1 facility scenario is completion of phase II of the SOC lodging plan, the +2 scenario is phase III, etc.

Figure 6.7 – Total-Cost Estimates, by Capacity Scenario, for FY03 Demand and a Contract-Quarters Price of $49

Expanding on Figure 6.7, Table 6.8 presents the annual-cost estimates, separated into on-base and off-base expenditures. The table shows how close the costs are between constructing one and two facilities. As in Table 6.7, the on-base occupancy rates for each capacity scenario are excluded, since they are unchanged from Table 6.1.

Table 6.8
Annual Costs for FY03 Demand with $49 Contract Quarters

Model Results	FY03	+ 1 Facility	+ 2 Facilities	+ 3 Facilities	+ 4 Facilities	+5 Facilities
Contract quarters cost ($ thousands)	2,868	1,572	661	208	55	18
On-base lodging cost ($ thousands)	11,121	12,025	12,912	13,781	14,638	15,491
Total cost average ($ thousands)	**13,989**	**13,597**	**13,574**	**13,990**	**14,693**	**15,508**
2 SD lower bound	13,679	13,324	13,357	13,841	14,598	15,452
2 SD upper bound	14,300	13,870	13,791	14,139	14,788	15,565

NOTES: The last capacity scenario (+ 6 facilities) is excluded from the table for ease of presentation. Total cost estimates are rising over this range. The confidence bounds are two standard deviations above and below the mean, which is roughly equivalent to the 95 percent confidence interval for total cost.

While it is unlikely that contract-quarters prices will fall further, a price decrease would make utilizing off-base quarters relatively more desirable. In this example, a $5 decrease did not alter the least-cost capacity, but it did decrease the cost difference between constructing one and two facilities from $116,000 to $23,000. Since the annual-cost difference between scenarios is small, a price decrease of $7 could alter the least-cost capacity. As a broader lesson, the recommended least-cost capacity is robust to changes in contract-quarters price unless the change is large and the cost differences between the efficient capacity and alternative scenarios is small. The policy recommendations are most sensitive to varying inputs when the cost differences between alternatives are small.

6.3.3 Shorter Facility Recapitalization Period

Section 5.4.4 explained that the capital costs of facility construction and scheduled renovations on the new facility are amortized over the life of the facility. The Air Force target recapitilization rate of 67 years was used as the assumed life span in this analysis. While a few of Maxwell's lodging facilities in use today were built during the 1940s, a 67-year lifespan may be an unrealistic assumption for the typical lodging facility. The

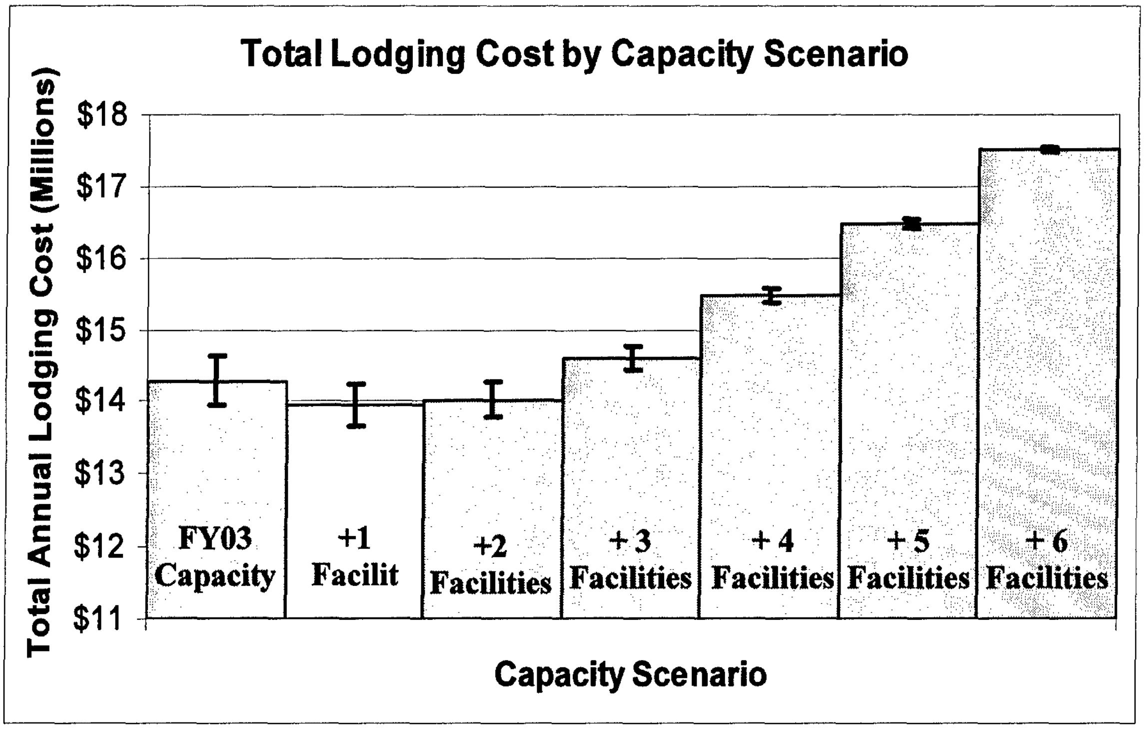
majority of Maxwell's facilities were constructed during the past 30 years. According to the Air Force Services Agency, the expected life span of newly constructed facilities is approximately 30 years. Lower, more-realistic recapitalization targets could replace the Air Force's 67-year target in analyses to determine the efficient number of lodging facilities. This analysis is flexible and can examine different amortization periods by altering the estimated capital cost. In this section, we consider an amortized facility life span of 30 years to evaluate whether the resulting higher annual amortized cost affects construction recommendations.

For a 67-year life span, the annual amortized cost per facility is $650,655.[180] For the shorter 30-year amortization, the annual cost increases to $843,100.[181] A higher annualized capital cost makes facility construction marginally less desirable, because each additional facility increases the annual cost by approximately $200,000. Figure 6.8 and Table 6.9 present the total-cost results for each capacity scenario. As in previous sections, the figure displays the aggregate picture and the table provides exact figures. The only change between these results and those presented in Section 6.1 is that scenarios with additional facilities have higher total costs of roughly $200,000 for each facility constructed.

---

[180] Section D.3 of Appendix D describes the methodology for amortizing capital costs over a 67-year life span to convert to an annual expense.

[181] Section D.3 of Appendix D also discusses the calculation for a 30-year amortization.



NOTES: The Y-axis scale is not normalized to zero to display confidence intervals. The +1 facility scenario is completion of phase II of the SOC lodging plan, the +2 scenario is phase III, etc.

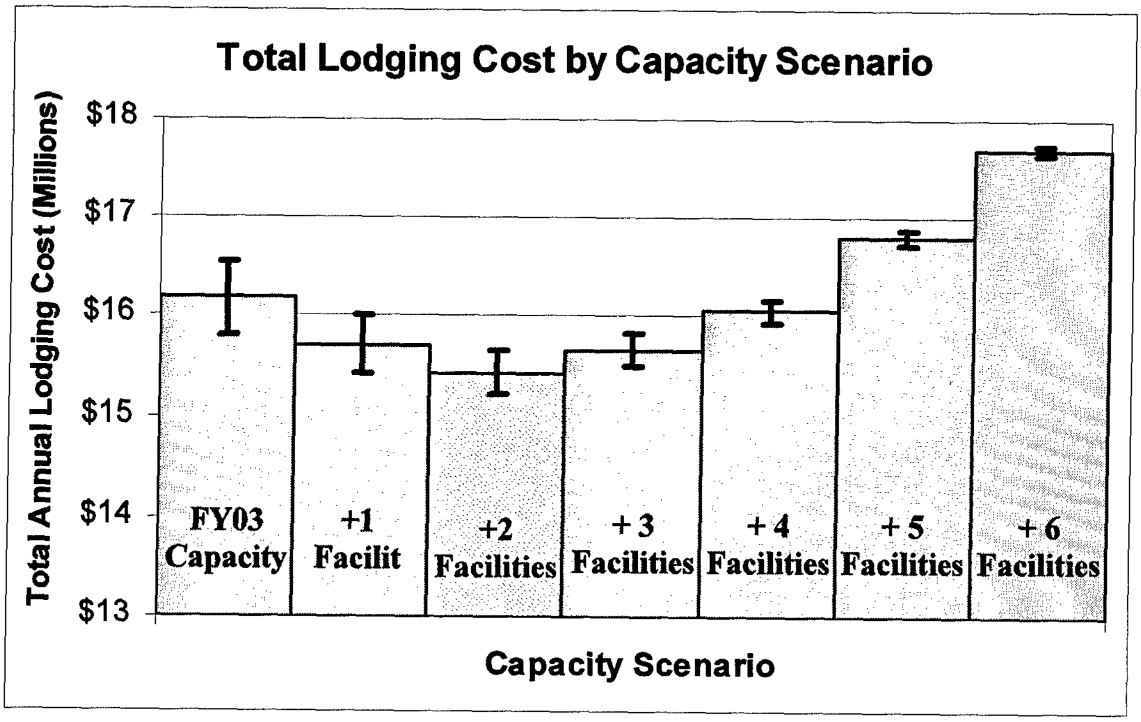
Figure 6.8 – Total-Cost Estimates, by Capacity Scenario, for FY03 Demand and 30-Year Amortization

Table 6.9
Total Annual Costs for FY03 Demand and 30-Year Amortization

Model Results	**FY03**	**+ 1 Facility**	**+ 2 Facilities**	**+ 3 Facilities**	**+ 4 Facilities**	**+5 Facilities**
Contract-quarters cost ($ thousands)	3,161	1,733	729	230	60	19
On-base lodging cost ($ thousands)	11,121	12,217	13,297	14,359	15,408	16,453
Total-cost average ($ thousands)	**14,282**	**13,950**	**14,026**	**14,588**	**15,468**	**16,473**
2 SD lower bound	13,941	13,650	13,787	14,425	15,364	16,411
2 SD upper bound	14,623	14,250	14,265	14,752	15,572	16,534

NOTES: The last capacity scenario (+ 6 facilities) is excluded from the table for ease of presentation. Total cost estimates are rising over this range. The confidence bounds are two standard deviations above and below the mean, which is roughly equivalent to the 95 percent confidence interval for total cost.

The result of the higher annual capital cost is that constructing additional facilities becomes marginally more expensive and less desirable. Recall that new construction is warranted when the cost savings from reduced contract quarters are greater than the additional on-base cost incurred by a new facility. For FY03 demand, the least-cost capacity constructs just one additional facility because of the additional capital charge for each new facility. For the higher FY04 demand, however, the least-cost capacity remains two additional facilities, even though scenarios with additional construction became comparatively less attractive because of higher costs. Figure 6.9 and Table 6.10 present the results for the FY04 data.



NOTES: The Y-axis scale is not normalized to zero to display confidence intervals. The +1 facility scenario is completion of phase II of the SOC lodging plan, the +2 scenario is phase III, etc.

Figure 6.9 – Total-Cost Estimates, by Capacity Scenario, for FY04 Demand and 30-Year Amortization

Table 6.10
Total Annual Costs for FY04 Demand and 30-Year Amortization

Model Results	FY03	+ 1 Facility	+ 2 Facilities	+ 3 Facilities	+ 4 Facilities	+5 Facilities
Contract quarters cost ($ thousands)	4,995	3,427	2,057	1,208	529	216
On-base lodging cost ($ thousands)	11,182	12,285	13,378	14,453	15,520	16,576
Total cost average ($ thousands)	**16,177**	**15,712**	**15,436**	**15,661**	**16,049**	**16,793**
2 SD lower bound	15,802	15,421	15,218	15,500	15,926	16,715
2 SD upper bound	16,551	16,003	15,653	15,822	16,172	16,870

NOTES: The last capacity scenario (+ 6 facilities) is excluded from the table for ease of presentation. Total cost estimates are rising over this range. The confidence bounds are two standard deviations above and below the mean, which is roughly equivalent to the 95 percent confidence interval for total cost.

The results in this section are important because they focus on the tradeoff between capital expenditures and future annual contract-quarters cost savings. In some cases, the chosen payback period determines whether or not new facility construction is cost-effective. While our analysis assumes the Air Force target recapitilization rate of 67 years, this section has illustrated that results can be adjusted for a shorter target payback period (i.e., 30 years), should the Air Force decide that a 67-year facility life is unrealistic. As with other sensitivity analyses, the policy recommendations are most sensitive to varying inputs when the cost differences between alternatives are small.

6.4 SUMMARY

This chapter has analyzed the model results to determine the efficient number of on-base lodging rooms. For FY03 demand, the recommended capacity scenario calls for constructing two additional facilities: phases II and III of the SOC lodging plan. The recommended least-cost capacity yields an annual on-base occupancy rate of 76 percent, significantly below the Air Force target of 85 percent, which again suggests the deficiency of this measure. The qualitative weighting example suggests that the

underestimate of contract quarters is insignificant in capacity determination unless the number of total contract quarters is high (>25,000) and the cost differences between the least-cost and next-largest-capacity scenarios are small.

Section 6.3 tested varying demand and cost parameters to ensure that our recommendations are robust and are not tailored to FY03. Facility recommendations were tested against the FY04 course schedules, an increased annual demand of approximately 70,000 bed spaces, varying contract-quarters prices, and a shorter expected facility life. Although both the demand increase and the higher contract-quarters price made constructing three facilities relatively more attractive than the baseline case, the least-cost capacity remained unchanged at two additional facilities in both cases. A decrease in contract-quarters prices makes lower capacities more desirable, but the least-cost capacity still calls for constructing two facilities. A 30-year facility life span, instead of the Air Force's 67-year target, increases the amortized annual cost for each newly constructed facility by approximately $200,000. As a result, capacity scenarios that require additional construction become marginally more expensive. For FY03 demand, the least-cost capacity shifts to constructing one additional facility because of higher capital costs for each new facility. The recommendations for FY04 are unchanged.

In determining the least-cost capacity, Air Force decisionmakers must determine what they believe represents a future annual demand profile and must evaluate their construction decision against other-than-expected demand scenarios. The chosen capacity can be adjusted to account for expectations of future demand or price changes in an effort to lower the risk due to uncertainty. Decisionmakers can use the results from this chapter (Figure 6.5) to assess the degree of inefficiency in overbuilding or underbuilding should the future demand profile change or additional decisionmaking criteria become applicable (i.e., per diem costs, transportation costs, unit cohesion, force protection, desire to minimize off-base utilization, etc.). The decisionmaker should consider these alternative objectives in choosing the capacity level, especially when the cost differences between scenarios are small.

7. THE MODEL AS TOOL FOR POLICY ANALYSIS: PROOF OF CONCEPT

Many Air Force managerial decisions—scheduling courses, establishing course linkages that necessitate overlap, determining on-base placements with the EMS weighting scheme, on-base/off-base movement policies—are made without a full understanding of their impact on total lodging costs. Historically, the Air Force has not prioritized lodging when considering the effect of large course-structure changes. This is not to say that lodging should dictate Air Force policies, only that the effect of policy choices on total lodging cost should be available and more transparent to the decisionmaker. In particular, the costs of achieving alternative objectives such as minimizing traveler movements or ensuring that a particular course is on-base should be better understood. Up to this point, it has been relatively difficult to project the effect of such changes on lodging due to the complexities of projecting contract quarters (Chapter 3).

This dissertation argues that estimating contract quarters requires an in-depth analysis of how lodging placement decisions are made. It develops a simulation tool that approximates the reservation system at Maxwell AFB, with which a decisionmaker can estimate the impact of lodging-related changes. For example, the effect of starting a new course, lengthening a course, or increasing course attendance can all be evaluated before policy implementation. Alternatively, the cost of current micro lodging policies can be analyzed to ensure that their benefits outweigh the additional costs they impose. As a proof of concept, this chapter analyzes two micro policies: (1) the AU course-weighting scheme against an alternative, more efficient course-ordering policy, and (2) relaxing the movement policy to allow moves after two days rather than five days in each location. Other analyzable micro policies include

- Changing movement policy to allow more than one move between on-base and off-base quarters.
- Course-scheduling changes that enforce a smoother flow of courses across the year.

7.1 ALTERING THE COURSE-WEIGHTING SCHEME

Section 2.4.2 discussed options for on-base priority schemes and described the current AU course-weighting system. The AU weighting scheme highlights the fact that maximizing on-base occupancy is not the top priority in lodging placement. Understandably, many priority factors besides course size and length are taken into account when deciding which courses should have priority for on-base lodging. However, the additional lodging cost associated with these other priorities must be balanced against the policy's benefit. Ensuring the transparency of this cost in decisionmaking is the objective of this section.

Using the simulation, this section compares the estimated cost of the current AU weighting scheme with that of an alternative ordering policy that prioritizes courses first by length and then by AU-assigned weight. Placing the longest courses first is the most efficient way to use the fixed on-base facility capacity.[182] This analysis determines how much more efficient it is than the current AU-weighting scheme. Table 7.1 presents the model results for each weighting scheme, holding constant the FY03 facility capacity and all other micro policies.

---

[182] In 1973, Johnson showed that a strategy that orders items from largest to smallest and then places them the first place they fit is never suboptimal by more than 22 percent and that no efficient bin-packing algorithm can be guaranteed to do better than 22 percent (Weisstein, n.d.).

Table 7.1
Course Priority-Weighting Comparison

Model Results	AU Course-Weighting	Placing Longest Courses First	Cost Savings
Annual contract-quarters cost ($)	3,161,192	2,742,600	418,592
Annual on-base lodging cost ($)	11,120,978	11,136,500	(15,522)
Annual total-cost average ($)	**14,282,170**	**13,879,100**	**403,070**
2 SD lower bound	13,940,963	13,508,853	
2 SD upper bound	14,623,378	14,249,346	
On-base occupancy (%)			
Without priority-two	79.2	80.3	
With priority-two	82.4	83.8	

Placing the longest courses first could save an estimated $403,070 per year by decreasing the number of contract quarters required, on average, by 7,752. However, the added efficiencies come at a price. Longer, lower-priority courses are placed before shorter, higher-priority courses. As an example, under this policy, the highly weighted entries—ORI IG team visit (weight = 103), Commissioned Officer Training for Reservists (weight = 77), Principles of Affirmative Employment (no weight), and Military Justice Administration (no weight)—place some attendees off-base, whereas all attendees are on-base under the AU course-weighting.[183] The preference to lodge these courses on-base is implicit in the AU course weights, the loss of which should be traded against the efficiency gains and cost savings of the alternative course ordering. The simulation allows AU personnel to evaluate various weighting schemes that balance the multiple objectives of minimizing contract quarters while ensuring that certain courses remain on-base.

[183] No-weight courses are placed before all other courses.

7.2 A TWO-DAY MOVEMENT RESTRICTION

The restrictions of moving only once and having to remain in each place for at least five days impose constraints on maximizing on-base occupancy. These policies are the main reasons the excess-demand measures at the daily level underestimate the number of contract quarters (Section 3.2.2). Multiday placement and movement restrictions constrain some on-base placements when on-base rooms are available for part but not all of a traveler's stay. This is not to say that these policies should be eliminated in the interest of maximizing occupancy, just that the costs of such policies should be transparent in decisionmaking. Evaluating the efficacy of these policies requires consideration of the tradeoff between their benefits (traveler and administrative convenience) and their costs (additional contract-quarters requirements). It is difficult to estimate the costs of these policies without a tool such as the simulation, because it is hard to predict which contract quarters would actually be saved by relaxing the movement restrictions.

In this example, the length-of-stay requirement is lowered from five days to two days. We then investigate the FY03 demand and capacity scenario with all other lodging policies held constant. We would expect more personnel to be able to stay on-base and a lower contract-quarters requirement because personnel sent off-base could return to on-base quarters more quickly. Table 7.2 presents the results of the movement-policy change.

Table 7.2
Results of Relaxing the Movement Restriction

Model Results	5-Day Restriction	2-Day Restriction	Cost Savings
Annual contract-quarters cost ($)	3,161,192	2,995,880	165,312
Annual on-base lodging cost ($)	11,120,978	11,121,616	(638)
Annual total-cost average ($)	**14,282,170**	**14,117,497**	**164,674**
2 SD lower bound	13,940,963	13,762,868	
2 SD upper bound	14,623,378	14,472,125	
On-base occupancy (%)			
Without priority-two	79.2	79.6	
With priority-two	82.4	82.9	

Relaxing the movement restriction saved fewer contract quarters than one might expect. On average, slightly more than 3,000 contract quarters were saved annually. Only a small fraction of the current contract quarters could be saved by reducing the movement restriction from five days to two days, because only a small number of students are being constrained by it. The effects are

1) The person who is making a move back to base can now do so three days earlier than before.
2) The person who was sent to contract quarters for his or her entire stay because on-base rooms were not available for five days at the beginning or end of a course can now be placed on-base for two, three, or four days at the beginning or end of the course.
3) Personnel attending courses shorter than nine days can stay in a combination of on-base and off-base quarters. With the five-day restriction, a person placed off-base for just one day would remain there for his or her entire stay. A two-day movement restriction allows courses as short as four days to utilize both on-base and off-base quarters.

In each case, these changes save only a small number of off-base bed nights. Since personnel can still move only once, this modification does nothing to avert contract quarters when on-base space is unavailable at the beginning and end of a stay but is available in the middle of the stay. It is also important to remember that contract quarters cannot be decreased below the difference between demand and available space without changes to demand, blocked spaces, or on-base capacity.[184] Adjustments to the movement restrictions can, at most, save the difference between the current number of contract quarters and excess demand (demand minus available space).

Enacting a more rigid movement policy in AETC Supplement 34-246 that required personnel to move back to on-base quarters after five days saved an estimated $500,000 in FY03. The large savings occurred because personnel placed off-base due to a lack of on-base vacancy at a single time in their stay could be returned to base for the rest of their stay. For some individuals with long courses, many contract-quarters bed nights are saved for each individual returned to base. Changing the policy from five days to two days has a smaller marginal effect because the number of bed nights saved in each case is small. The lesson here is that cost savings from enforcing a stricter movement policy without changing the move-only-once restriction become marginally smaller as the number of bed nights that could be saved for each individual decreases.

7.3 SUMMARY

As a proof of concept, this chapter exercised the model to evaluate two important micro lodging-policy decisions: course scheduling and movement restrictions. Many lodging-management policies are made without a full understanding of their effect on total lodging costs (e.g., schools create their own course schedules). The simulation model provides an analytic tool for estimating the effect of some micro lodging-management policies to better inform decisionmakers faced with multiobjective decisions

---

[184] In FY03, the difference between demand and available space at the daily level was 28,498 (Table 3.3). Without changes to demand, blocked spaces, or capacity, this is overflow demand and will require contract quarters no matter what micro lodging policies are in place.

that require tradeoffs. Section 7.1 showed that approximately $400,000 of contract-quarters cost could be avoided by scheduling the longest courses first. These cost savings would have to be traded against the loss of prioritization from the current AU weighting scheme, as some highly weighted courses would be pushed off-base. In Section 7.2, relaxing the length-of-stay restriction from five days to two days in the same location had only a small impact on contract-quarters costs. This unexpected result occurs because only a few types of personnel would be affected by this change, and the number of contract quarters saved for each individual is small. Limiting personnel to moving only once appears to be the more costly movement restriction.

8. FINDINGS AND CONCLUSIONS

This dissertation outlines a new methodology that provides better estimates for the actual contract-quarters requirement at Air Force bases, allowing more-accurate capacity-tradeoff analyses. Metrics and methodologies currently employed by the Air Force and other services underestimate the need for on-base lodging facilities by underestimating the number of contract quarters at a chosen on-base capacity. This analysis shows that a simple difference of demand and supply, even at the daily level, is a bad predictor of actual contract quarters. Beyond documenting the deficiency, this dissertation provides an alternative methodology to improve capacity right-sizing within DoD. The modeling tool developed here can also assess the impact of various lodging policies on cost. It explores the effect of macro (on-base capacity size) and micro (lodging management) policies on lodging costs, both on-base and off-base.

Looking first at the macro policy, right-sizing capital infrastructure is a difficult problem requiring more-complex analytic modeling than is currently being employed by the Air Force or the Army. Current methodologies for determining the "efficient" capacity are inadequate. On-base utilization rates are the primary managerial metric used in capacity determination by the Air Force, but these aggregate metrics do not account for important factors that affect the cost-minimizing-capacity decision, such as the seasonality of demand, daily-demand variability, or the contract-quarters price, which can lead to capacity determinations that do not minimize total lodging cost. Minimizing the combined cost to the government of on-base and off-base quarters should be a leading objective in the capacity decision.

At times, the Air Force goes beyond aggregate metrics and performs formal tradeoff analyses to determine the least-cost capacity level. However, the methodologies employed by the Air Force needs assessments and the Army's right-sizing model underestimate the actual contract-quarters requirement by using aggregated data and assuming too much efficiency in on-base facility utilization. Aggregating data into weekly or monthly averages conceals important phenomena occurring at the daily level, such as demand spikes, that must be considered in capacity determination. The studies

neglect on- and off-base movement restrictions and other lodging micro policies that enforce placement criteria that span multiple days and constrain some on-base placements. Tradeoff analyses that ignore these factors and utilize lower off-base estimates will recommend efficient capacity levels that are, in general, too low.

For better capacity determinations, tradeoff analyses should (1) utilize daily supply and demand data and (2) more accurately estimate the actual on- and off-base facility placements. The aggregation of daily-occupancy data into monthly or annual averages is a primary reason for the incorrect capacity recommendations resulting from both the annual-occupancy metrics and the needs assessments. The recent improved capability to export daily-occupancy data from LTS should allow future tradeoff analyses to utilize daily data and thereby ameliorate this problem, which accounts for just less than half of the understated contract quarters at Maxwell AFB, the example used in this study. As discussed, however, even daily data cannot fully account for the lodging management policies that constrain some on-base placements and necessitate contract quarters beyond those predicted by daily supply and demand alone. To correct this problem, analytic models must generate hypothetical lodging placements based on lodging management rules, movement restrictions, course schedules, individual stay lengths, required facility types, and a host of other factors. Simply put, tradeoff analyses used for capacity determination must do better at estimating the actual contract-quarters requirement for a given demand pattern and on-base capacity.

This dissertation outlines a tradeoff analysis that improves upon current methods. The new methodology develops a simulation model, based on the inventory-theory literature, that replicates the lodging reservation system at Maxwell AFB.[185] The model provides improved estimates of the off-base lodging requirement by accounting for course attendees whose lodging placements depend upon a list of factors spanning the length of the course. Better estimates for the actual lodging placements will improve the accuracy of the tradeoff analyses. Lodging-cost functions, for both on- and off-base

---

[185] The inventory literature's standard daily model, which accounts for shortages by differencing supply and demand, does not sufficiently capture all shortages.

facilities, are estimated from Maxwell's cost data and applied to the simulation's more-accurate facility placements to generate total lodging costs. It is recommended that AETC/FM review the cost estimates to ensure that all relevant costs are included and that the estimations are consistent with AETC estimates.[186] The simulation evaluates different supply capacities to determine the least-cost size of Maxwell's lodging operation for a given demand distribution.

Chapter 6 included specific model results for our case study. For FY03 demand, the efficient capacity level requires construction of two additional facilities, phase II and phase III of the SOC lodging plan. The Air Force is on track, having opened phase II in January 2004 and appropriated funding for phase III in FY04. At this least-cost capacity, on-base occupancy rates are projected to be approximately 76 percent, below the 85 percent Air Force target, which again suggests the deficiency of using utilization alone as the evaluation metric. It is important to remember that these facility recommendations are contingent upon the FY03 demand distribution, and changes to demand could affect them. The growth of Maxwell's training programs since FY00 did not slow in FY04, requiring an additional 70,000 bed spaces. Despite the demand increase, the FY04 analysis also recommended construction of two additional facilities; however, constructing a third facility became a relatively more attractive policy option. Total-cost estimates for constructing either two or three facilities were approximately equal, allowing the decision to be made according to criteria other than cost.

To determine the efficient facility capacity, Air Force decisionmakers must define what they believe represents a future annual-demand profile, and they must evaluate their preferred construction decision against other-than-expected demand scenarios. Since facility construction requires a substantial initial investment and a lengthy payback period, the simulation should not be used to determine the optimal facility capacity for one specific year, where the demand profile may not be representative of the past or of

[186] After this study was completed, it was discovered that per diem rates for food can vary between on- and off-base facilities. This cost difference was not included in this analysis but would affect capacity determination. In general, the inclusion of these costs would make additional construction relatively more desirable.

future projections. Instead, the simulation is useful as a macro planning tool for capacity determination based on projected future annual-demand profiles. Decisionmakers can use the full model results to assess the degree of inefficiency in overbuilding or underbuilding, should the future-demand profile change or additional decisionmaking criteria (e.g., unit cohesion, force protection, desire to minimize off-base utilization) become applicable. Additionally, other sensitivity analyses discussed in Chapter 6 allow the decisionmaker to evaluate the effect of varying some key input parameters.

Apart from being a capacity right-sizing tool, the simulation is useful for estimating the effect of lodging's management policies on total cost. Strategic managerial decisions such as scheduling courses, establishing course linkages that necessitate overlap, the course weighting scheme, and on-base/off-base movement policies are often made with little or no understanding of the impact on total lodging cost. Up to this point, it has been relatively difficult to predict the effect of these changes on lodging because of the complexities of projecting the resulting facility placements and contract quarters. The simulation provides a planning tool for estimating the impact of lodging-related policy changes by accurately projecting on-base and off-base facility placements.

Although the model was narrowly tailored to replicate several Maxwell-specific placement rules (e.g., AU course-weighting), its framework is generalizable to other Air Force or DoD lodging operations, given that data exist on individual demanders (i.e., length of stay, start and end dates, facility preferences, etc.). More broadly, the methodological shortcomings of right-sizing metrics (Chapter 3) are applicable to any right-sizing problem with daily-demand variability, seasonality, and placement criteria that span multiple days.

Acknowledging and addressing these methodological issues in current Air Force and Army models is a necessary first step. Decisionmakers who wish to improve on current right-sizing metrics and models have two alternatives. The more-accurate, but resource-intensive method would be to adopt the simulation tool presented in this dissertation. This would require a commitment of analytic resources to exercise the model at multiple installations. At a minimum, it would also necessitate a base-by-base evaluation of demand and base-specific cost functions.

If this more-advanced simulation model is not adopted, current right-sizing methods could still be improved with a less-substantial commitment of analytic resources. The new capability to extract daily occupancy data from LTS should allow, and arguably necessitate, the use of daily data in future excess-demand tradeoff analyses, a vast improvement over monthly averages. This would eliminate the underestimates resulting from data aggregation but would not correct for the multiday placement and movement restrictions that make excess-demand metrics an imprecise predictor of contract quarters at the daily level. If continued use of more-simplistic excess-demand (demand minus supply) methodologies to project contract quarters is necessary, it must be remembered that they will underestimate the contract-quarters requirement, so capacity recommendations should be adjusted accordingly. The resulting tradeoff analyses should be qualitatively weighted to account for the systematic underestimation of contract quarters, calculated here to be more than half of the totals in FY03, which will affect construction recommendations. More work will be needed on estimating the magnitude of this bias at bases other than Maxwell so that results can be appropriately weighted.

Although additional changes could be made to enhance the analytic tool, particularly in the area of better cost estimates, the model developed in this dissertation provides a significantly more-accurate means of determining the cost-minimizing number of lodging facilities at a base. It demonstrates that current managerial metrics and tradeoff analyses often do not yield the cost-minimizing number of on-base facilities. The simulation tool has the flexibility to be used for a variety of capital-infrastructure policy decisions, both macro (capacity determination) and micro (lodging management). It enables more-accurate contract-quarter projections, yielding better tradeoff analyses and giving decisionmakers better information on the costs of lodging.

APPENDIX A. COURSE LISTING AT MAXWELL AND GUNTER

Title	Course Weight	Start Date	End Date	Total
MILITARY JUSTICE ADMINISTRATION COURSE	No Weight	3-Nov-02	8-Nov-02	136
DEPLOYED FISCAL LAW AND CONTINGENCY CONTRACT	No Weight	12-Nov-02	16-Nov-02	140
ACCIDENT INVESTIGATION BOARD LEGAL ADVISOR	No Weight	11-Feb-03	14-Feb-03	80
PRINCIPLES OF AFFIRMATIVE EMPLOYMENT	No Weight	2-Mar-03	21-Mar-03	44
NATIONAL SECURITY FORUM	120	26-May-03	30-May-03	150
AU BOARD OF VISITORS	106	17-Nov-02	20-Nov-02	25
ORI IG TEAM VISIT	103	21-Apr-03	3-May-03	145
ACSC INTERNATIONAL OFFICER SCHOOL COURSE	88	9-Jun-03	25-Jul-03	15
AWC INTERNATIONAL OFFICER SCHOOL COURSE	87	2-Jun-03	18-Jul-03	7
JOINT FLAG OFF WARFIGHTING	82	6-Sep-03	19-Sep-03	18
COMBINED FORCES AIR COMPONENT COMMANDER	81	9-Aug-03	16-Aug-03	18
COMMISSIONED OFFICER TRAINING (COT)	80	1-Oct-02	31-Oct-02	76
SENIOR INFORMATION WARFARE APPLICATIONS	80	11-Nov-02	16-Nov-02	16
COMMISSIONED OFFICER TRAINING (COT)	80	18-Nov-02	20-Dec-02	79
COMMISSIONED OFFICER TRAINING (COT)	80	7-Jan-03	5-Feb-03	105
COMMISSIONED OFFICER TRAINING (COT)	80	11-Feb-03	12-Mar-03	80
COMMISSIONED OFFICER TRAINING (COT)	80	28-Apr-03	29-May-03	122
SENIOR INFORMATION	80	12-May-03	16-May-03	14

WARFARE APPLICATIONS				
COMMISSIONED OFFICER TRAINING (COT)	80	8-Jul-03	8-Aug-03	53
COT FOR THE RESERVE COMPONENT	77	1-Nov-02	17-Nov-02	145
COT FOR THE RESERVE COMPONENT	77	22-Mar-03	6-Apr-03	161
SOS INTERNATIONAL OFFICER SCHOOL COURSE	75	1-Oct-02	3-Nov-02	30
WORLD WIDE COMMAND CHIEF CONFERENCE	73	24-Apr-03	29-Apr-03	300
JLASS WARGAME	71	30-Mar-03	5-Apr-03	82
JLASS CONTROL	70	27-Mar-03	5-Apr-03	100
GATHERING OF EAGLES	67	4-Jun-03	8-Jun-03	40
AF SNCOA ACADEMY GRADUATION (CMSAF AND MAJCOM)	66	17-Nov-02	21-Nov-02	49
AF SNCOA ACADEMY GRADUATION (CMSAF AND MAJCOM)	66	18-Nov-02	21-Nov-02	25
AF SNCOA ACADEMY GRADUATION (CMSAF AND MAJCOM)	66	18-Nov-02	21-Nov-02	15
AF SNCOA ACADEMY GRADUATION (CMSAF AND MAJCOM)	66	25-Feb-03	28-Feb-03	25
AF SNCOA ACADEMY GRADUATION (CMSAF AND MAJCOM)	66	15-Jun-03	19-Jun-03	15
AF SNCOA ACADEMY GRADUATION (CMSAF AND MAJCOM)	66	2-Sep-03	5-Sep-03	25
SES AIR AND SPACE POWER	64	15-Oct-02	18-Oct-02	20
US COAST GUARD SILVER BADGE CONFERENCE	62	6-Jan-03	9-Jan-03	72
PARALEGAL APPRENTICE COURSE	60	5-Jan-03	19-Feb-03	32

PARALEGAL APPRENTICE COURSE	60	9-Mar-03	21-Apr-03	30
PARALEGAL APPRENTICE COURSE	60	27-Apr-03	10-Jun-03	32
PARALEGAL APPRENTICE COURSE	60	22-Jun-03	5-Aug-03	32
PARALEGAL APPRENTICE COURSE	60	10-Aug-03	23-Sep-03	32
AIR WAR COLLEGE RESIDENT PROGRAM	59	1-Oct-02	2-Jun-03	15
CHAPLAIN SERVICE SUPPORT APPRENTICE COURSE	59	6-Oct-02	15-Nov-02	30
CHAPLAIN SERVICE SUPPORT APPRENTICE COURSE	59	12-Jan-03	21-Feb-03	30
CHAPLAIN SERVICE SUPPORT APPRENTICE COURSE	59	2-Mar-03	11-Apr-03	30
CHAPLAIN SERVICE SUPPORT APPRENTICE COURSE	59	4-May-03	13-Jun-03	30
CHAPLAIN SERVICE SUPPORT APPRENTICE COURSE	59	29-Jun-03	8-Aug-03	28
AIR WAR COLLEGE-RESIDENT	59	27-Jul-03	1-Oct-03	10
SUMMITT III	58	7-Apr-03	10-Apr-03	32
AIR COMMAND AND STAFF COLLEGE RESIDENT COURSE	57	1-Oct-02	10-Jun-03	12
HISTORIAN APPRENTICE COURSE	57	5-Jan-03	31-Jan-03	13
NCO ACADEMY- GUNTER ANNEX	57	17-Feb-03	27-Mar-03	190
HISTORIAN APPRENTICE COURSE	57	30-Mar-03	23-Apr-03	12
NCO ACADEMY- GUNTER ANNEX	57	7-Apr-03	16-May-03	190
NCO ACADEMY- GUNTER ANNEX	57	21-May-03	2-Jul-03	190
HISTORIAN APPRENTICE COURSE	57	1-Jun-03	26-Jun-03	14

AIR COMMAND AND STAFF COLLEGE RESIDENT COURSE	57	6-Jun-03	1-Oct-03	10
NCO ACADEMY- GUNTER	57	30-Jul-03	10-Sep-03	190
HISTORIAN APPRENTICE COURSE	57	2-Sep-03	27-Sep-03	14
NCO ACADEMY- GUNTER	57	17-Sep-03	1-Oct-03	190
SQUADRON OFFICER SCHOOL	56	1-Oct-02	5-Oct-02	390
USAF SENIOR NCO ACADEMY	56	7-Oct-02	21-Oct-02	363
USAF SENIOR NCO ACADEMY	56	14-Jan-03	28-Feb-03	377
USAF SENIOR NCO ACADEMY	56	12-Mar-03	24-Apr-03	363
USAF SENIOR NCO ACADEMY	56	6-May-03	19-Jun-03	363
USAF SENIOR NCO ACADEMY	56	19-Jul-03	5-Sep-03	363
AEROSPACE BASIC COURSE	55	1-Oct-02	4-Oct-02	644
AIR AND SPACE BASIC COURSE	55	14-Oct-02	8-Nov-02	644
SQUADRON OFFICER SCHOOL	55	3-Nov-02	11-Dec-02	390
TOPS IN BLUE	55	4-Nov-02	5-Nov-02	32
AIR AND SPACE BASIC COURSE	55	19-Nov-02	19-Dec-02	611
SQUADRON OFFICER SCHOOL	55	5-Jan-03	7-Feb-03	390
AIR AND SPACE BASIC COURSE	55	12-Jan-03	8-Feb-03	644
SQUADRON OFFICER SCHOOL	55	23-Feb-03	29-Mar-03	390
AIR AND SPACE BASIC COURSE	55	2-Mar-03	28-Mar-03	601
SQUADRON OFFICER SCHOOL	55	6-Apr-03	9-May-03	358
AIR AND SPACE BASIC COURSE	55	13-Apr-03	10-May-03	581
AFJAG SCHOOL FOUNDATION MEETING	55	16-May-03	17-May-03	25
SQUADRON OFFICER SCHOOL	55	26-May-03	28-Jun-03	390
AIR AND SPACE BASIC COURSE	55	1-Jun-03	27-Jun-03	504
AIR AND SPACE BASIC COURSE	55	20-Jul-03	4-Sep-03	623
SQUADRON OFFICER SCHOOL	55	20-Jul-03	22-Aug-03	390
SQUADRON OFFICER SCHOOL	55	1-Sep-03	1-Oct-03	390
SENIOR EXECUTIVE SERVICE SEMINAR	54	9-Jun-03	13-Jun-03	8

AIR FORCE RESERVE BAND	53	20-Nov-02	21-Nov-02	5
AIR FORCE RESERVE BAND	53	25-Feb-03	26-Feb-03	6
AIR FORCE RESERVE BAND	53	27-Feb-03	28-Feb-03	5
AIR FORCE RESERVE BAND	53	27-Feb-03	28-Feb-03	7
AIR FORCE RESERVE BAND	53	14-Mar-03	15-Mar-03	6
AIR FORCE RESERVE BAND	53	14-Apr-03	15-Apr-03	3
AIR FORCE RESERVE BAND	53	23-Apr-03	24-Apr-03	5
AIR FORCE RESERVE BAND	53	21-May-03	22-May-03	7
AIR FORCE RESERVE BAND	53	29-May-03	1-Jun-03	8
AIR FORCE RESERVE BAND	53	5-Jun-03	8-Jun-03	45
AIR FORCE RESERVE BAND	53	18-Jun-03	19-Jun-03	5
AIR FORCE RESERVE BAND	53	4-Sep-03	5-Sep-03	5
AIR FORCE RESERVE BAND	53	13-Sep-03	14-Sep-03	8
AIR FORCE RESERVE BAND	53	17-Sep-03	18-Sep-03	5
AIR FORCE RESERVE BAND	53	29-Sep-03	30-Sep-03	5
MILITARY BAND PEFORMANCE	52	8-Dec-02	10-Dec-02	12
MILITARY BAND PEFORMANCE	52	26-May-03	27-May-03	21
HOME LAND SECURITY WARGAME	50	2-Jun-03	5-Jun-03	110
JUDGE ADVOCATE STAFF OFFICER COURSE	49	6-Oct-02	11-Dec-02	49
JUDGE ADVOCATE STAFF OFFICER COURSE	49	10-Feb-03	11-Apr-03	65
JUDGE ADVOCATE STAFF OFFICER COURSE	49	20-Jul-03	19-Sep-03	45
FIRST SERGEANT ACADEMY	46	23-Oct-02	22-Nov-02	34
FIRST SERGEANT ACADEMY	46	27-Jan-03	26-Feb-03	42
FIRST SERGEANT ACADEMY	46	23-Mar-03	19-Apr-03	22
FIRST SERGEANT ACADEMY	46	23-Apr-03	22-May-03	24
FIRST SERGEANT ACADEMY	46	9-Jul-03	7-Aug-03	37
FIRST SERGEANT ACADEMY	46	19-Aug-03	18-Sep-03	38

STAFF JUDGE ADVOCATE	45	15-Jun-03	27-Jun-03	45
ENVIRONMENTAL LAW	43	17-Nov-02	22-Nov-02	86
ANG FIRST SERGEANT ACAD.	42	6-Oct-02	19-Oct-02	30
ANG FIRST SERGEANT ACAD.	42	1-Dec-02	14-Dec-02	32
ANG FIRST SERGEANT ACAD.	42	5-Jan-03	18-Jan-03	32
SAFETY AND ACCIDENT INVESTIGATION BOARD PRESIDENTS COURSE	42	28-Jan-03	1-Feb-03	15
MISSION SUPPORT GROUP COMMANDERS COURSE	42	2-Feb-03	12-Feb-03	14
OPERATIONS GROUP COMMANDERS COURSE	42	3-Feb-03	14-Feb-03	24
ANG FIRST SERGEANT ACAD.	42	2-Mar-03	15-Mar-03	31
SAFETY AND ACCIDENT INVESTIGATION BOARD PRESIDENTS COURSE	42	11-Mar-03	15-Mar-03	15
MISSION SUPPORT GROUP COMMANDERS COURSE	42	16-Mar-03	29-Mar-03	12
OPERATIONS GROUP COMMANDERS COURSE	42	16-Mar-03	29-Mar-03	22
SAFETY AND ACCIDENT INVESTIGATION BOARD PRESIDENTS COURSE	42	29-Apr-03	3-May-03	15
MISSION SUPPORT GROUP COMMANDERS COURSE	42	4-May-03	17-May-03	15
OPERATIONS GROUP COMMANDERS COURSE	42	4-May-03	17-May-03	25
ANG FIRST SERGEANT ACAD.	42	1-Jun-03	14-Jun-03	34
SAFETY AND ACCIDENT INVESTIGATION BOARD PRESIDENTS COURSE	42	10-Jun-03	14-Jun-03	15
OPERATIONS GROUP COMMANDERS COURSE	42	10-Jun-03	28-Jun-03	25
MISSION SUPPORT GROUP COMMANDERS COURSE	42	15-Jun-03	28-Jun-03	14
SAFETY AND ACCIDENT INVESTIGATION BOARD	42	15-Jul-03	19-Jul-03	15

PRESIDENTS COURSE				
MISSION SUPPORT GROUP COMMANDERS COURSE	42	20-Jul-03	2-Aug-03	16
OPERATIONS GROUP COMMANDERS COURSE	42	20-Jul-03	2-Aug-03	15
ANG FIRST SERGEANT ACAD.	42	21-Sep-03	1-Oct-03	45
GS15 LEADERSHIP SEMINAR	41	2-Feb-03	7-Feb-03	24
GS15 LEADERSHIP SEMINAR	41	8-Jun-03	13-Jun-03	21
GS15 LEADERSHIP SEMINAR	41	3-Aug-03	8-Aug-03	24
GS15 LEADERSHIP SEMINAR	41	7-Sep-03	12-Sep-03	24
WING COMMANDERS COURSE	40	26-Jan-03	1-Feb-03	14
MAINTENANCE GROUP COMMANDERS COURSE	40	2-Feb-03	13-Feb-03	11
WING COMMANDERS COURSE	40	23-Feb-03	1-Mar-03	53
MAINTENANCE GROUP COMMANDERS COURSE	40	16-Mar-03	28-Mar-03	10
WING COMMANDERS COURSE	40	27-Apr-03	3-May-03	22
MAINTENANCE GROUP COMMANDERS COURSE	40	16-Jun-03	28-Jun-03	10
MAINTENANCE GROUP COMMANDERS COURSE	40	20-Jul-03	2-Aug-03	10
WING COMMANDERS COURSE	40	24-Aug-03	30-Aug-03	23
MEDICAL GROUP COMMANDERS COURSE	39	16-Mar-03	29-Mar-03	12
MEDICAL GROUP COMMANDERS COURSE	39	15-Jun-03	28-Jun-03	15
ROTC INSTRUCTOR COURSE	38	4-May-03	23-May-03	120
ROTC INSTRUCTOR COURSE	38	1-Jun-03	20-Jun-03	88
ACADEMIC INSTRUCTOR	37	1-Oct-02	4-Oct-02	62
ACADEMIC INSTRUCTOR	37	20-Oct-02	15-Nov-02	62
SOS INTERNATIONAL OFFICER SCHOOL COURSE	37	30-Dec-02	28-Mar-03	28
ACADEMIC INSTRUCTOR	37	5-Jan-03	31-Jan-03	62
ENVIRONMENTAL LAW	37	28-Jan-03	2-Feb-03	106

UPDATE COURSE				
ACADEMIC INSTRUCTOR	37	9-Feb-03	7-Mar-03	62
ACADEMIC INSTRUCTOR	37	30-Mar-03	25-Apr-03	62
SOS INTERNATIONAL OFFICER SCHOOL COURSE	37	31-Mar-03	17-May-03	31
BASIC MEDIATION COURSE	37	1-Jun-03	6-Jun-03	22
ACADEMIC INSTRUCTOR	37	1-Jun-03	27-Jun-03	16
ACADEMIC INSTRUCTOR	37	15-Jun-03	11-Jul-03	25
ACADEMIC INSTRUCTOR	37	3-Aug-03	29-Aug-03	62
ACADEMIC INSTRUCTOR	37	7-Sep-03	1-Oct-03	58
SOS INTERNATIONAL OFFICER SCHOOL COURSE	37	8-Sep-03	1-Oct-03	32
PROFESSIONAL MILITARY COMPTROLLER COURSE	36	6-Oct-02	15-Nov-02	36
PROFESSIONAL MILITARY COMPTROLLER COURSE	36	12-Jan-03	21-Feb-03	55
TOTAL AIR FORCE OPERATIONS LAW COURSE	36	20-Feb-03	23-Feb-03	100
PARALEGAL CRAFTSMAN COURSE	36	2-Mar-03	10-Apr-03	82
PROFESSIONAL MILITARY COMPTROLLER COURSE	36	23-Mar-03	2-May-03	53
MILITARY JUDGES' SEMINAR	36	21-Apr-03	26-Apr-03	120
OPERATIONS LAW COURSE	36	5-May-03	17-May-03	140
PROFESSIONAL MILITARY COMPTROLLER COURSE	36	1-Jun-03	11-Jul-03	58
PARALEGAL CRAFTSMAN COURSE	36	3-Aug-03	15-Sep-03	91
PROFESSIONAL MILITARY COMPTROLLER COURSE	36	3-Aug-03	12-Sep-03	28
RESERVE FORCES JUDGE ADVOCATE	35	6-Oct-02	11-Oct-02	100
CONTINGENCY WARTIME PLANNING	35	20-Oct-02	1-Nov-02	75
FEDERAL INCOME TAX LAW	35	1-Dec-02	6-Dec-02	122

COURSE				
CONTINGENCY WARTIME PLANNING	35	1-Dec-02	13-Dec-02	75
RESERVE PROFESSIONAL MILITARY COMPTROLLER	35	1-Dec-02	13-Dec-02	60
CONTINGENCY WARTIME PLANNING	35	5-Jan-03	17-Jan-03	75
EMPLOYEE-MANAGEMENT RELATIONS ADVANCED	35	27-Jan-03	6-Feb-03	43
CLAIMS AND TORT LITIGATION COURSE	35	2-Feb-03	11-Feb-03	64
CONTINGENCY WARTIME PLANNING	35	23-Feb-03	7-Mar-03	77
CONTINGENCY WARTIME PLANNING	35	23-Mar-03	4-Apr-03	77
CONTINGENCY WARTIME PLANNING	35	20-Apr-03	2-May-03	77
NEGOTIATION AND APPROPRIATE DISPUTE RESOLUTION COURSE	35	11-May-03	16-May-03	72
LAW OFFICE MANAGERS	35	15-Jun-03	27-Jun-03	63
RESERVE FORCES JUDGE ADVOCATE	35	6-Jul-03	11-Jul-03	100
CONTINGENCY WARTIME PLANNING	35	6-Jul-03	18-Jul-03	75
CONTINGENCY WARTIME PLANNING	35	20-Jul-03	1-Aug-03	75
CONTINGENCY WARTIME PLANNING	35	17-Aug-03	29-Aug-03	80
CONTINGENCY WARTIME PLANNING	35	14-Sep-03	26-Sep-03	75
BASIC CHAPLAIN COURSE	34	20-Oct-02	16-Nov-02	16
FEDERAL EMPLOYEE LABOR LAW	34	20-Oct-02	25-Oct-02	79
AFROTC NCO ACADEMY ORIENTATION	34	20-Oct-02	2-Nov-02	20
JOINT AIR OPERATIONS	34	20-Oct-02	1-Nov-02	31

PLANNING COURSE				
CHAPLAIN ASSISTANT CRAFTSMAN COURSE	34	1-Dec-02	13-Dec-02	25
JOINT AIR OPERATIONS PLANNING COURSE	34	1-Dec-02	13-Dec-02	31
TRIAL & DEFENSE ADVOCACY	34	5-Jan-03	10-Jan-03	36
JOINT AIR OPERATIONS PLANNING COURSE	34	5-Jan-03	17-Jan-03	31
BASIC CHAPLAIN COURSE	34	26-Jan-03	22-Feb-03	28
AFROTC NCO ORIENTATION COURSE	34	26-Jan-03	8-Feb-03	27
EEO MANAGERS COURSE	34	23-Feb-03	28-Feb-03	56
JOINT AIR OPERATIONS PLANNING COURSE	34	23-Feb-03	7-Mar-03	31
JOINT AIR OPERATIONS PLANNING COURSE	34	23-Mar-03	4-Apr-03	31
CHAPLAIN ASSISTANT CRAFTSMAN COURSE	34	30-Mar-03	11-Apr-03	30
ADVANCED POSITION CLASSIFICATION COURSE	34	31-Mar-03	10-Apr-03	58
JOINT AIR OPERATIONS PLANNING COURSE	34	20-Apr-03	2-May-03	33
TRIAL AND DEFENSE ADVOCACY	34	27-Apr-03	2-May-03	36
LABOR RELATIONS COURSE	34	12-May-03	23-May-03	44
ADVANCED LABOR AND EMPLOYMENT LAW COURSE	34	18-May-03	23-May-03	56
JOINT AIR OPERATIONS PLANNING COURSE	34	6-Jul-03	18-Jul-03	31
BASIC CHAPLAIN COURSE	34	13-Jul-03	9-Aug-03	31
TRIAL AND DEFENSE ADVOCACY	34	13-Jul-03	18-Jul-03	36
ADVANCED AFFIRMATIVE EMPLOYMENT COURSE	34	14-Jul-03	25-Jul-03	45
JOINT AIR OPERATIONS PLANNING COURSE	34	20-Jul-03	1-Aug-03	41

AFROTC NCO ORIENTATION	34	27-Jul-03	9-Aug-03	40
INTERMEDIATE POSITION CLASSIFICATION COURSE	34	4-Aug-03	14-Aug-03	51
CHAPLAIN ASSISTANT CRAFTSMAN COURSE	34	10-Aug-03	22-Aug-03	25
CHAPLAIN ASSISTANT CRAFTSMAN COURSE	34	10-Aug-03	23-Aug-03	30
JOINT AIR OPERATIONS PLANNING COURSE	34	17-Aug-03	29-Aug-03	36
CHAPLAIN ASSISTANT CRAFTSMAN COURSE	34	7-Sep-03	19-Sep-03	30
INFORMATION WARFARE APPLICATIONS COURSE	33	6-Oct-02	11-Oct-02	90
MANPOWER AND STAFF OFFICER COURSE (MSOC)	33	20-Oct-02	8-Nov-02	18
INFORMATION WARFARE APPLICATIONS COURSE	33	3-Nov-02	8-Nov-02	83
INTERMEDIATE CHAPLAIN COURSE	33	1-Dec-02	14-Dec-02	32
MANPOWER AND STAFF OFFICER COURSE (MSOC)	33	26-Jan-03	14-Feb-03	20
ADVANCED ENVIRONMENTAL LAW COURSE	33	26-Jan-03	30-Jan-03	65
INFORMATION WARFARE APPLICATIONS COURSE	33	26-Jan-03	31-Jan-03	62
INFORMATION WARFARE APPLICATIONS COURSE	33	9-Feb-03	14-Feb-03	72
INTERMEDIATE CHAPLAIN COURSE	33	2-Mar-03	15-Mar-03	29
INFORMATION WARFARE APPLICATIONS COURSE	33	9-Mar-03	14-Mar-03	53
MANPOWER AND STAFF OFFICER COURSE (MSOC)	33	16-Mar-03	4-Apr-03	20
INFORMATION WARFARE APPLICATIONS COURSE	33	6-Apr-03	11-Apr-03	58
WING CHAPLAIN COURSE	33	27-Apr-03	9-May-03	22
RESERVE FORCES PARALEGAL	33	1-Jun-03	13-Jun-03	70

COURSE				
EMPLOYEE MANAGEMENT RELATIONS COURSE	33	16-Jun-03	27-Jun-03	58
MANPOWER AND STAFF OFFICER COURSE (MSOC)	33	13-Jul-03	1-Aug-03	20
AF JROTC ACADEMIC INSTRUC	33	13-Jul-03	25-Jul-03	75
RESERVE FORCES PARALEGAL	33	20-Jul-03	25-Jul-03	50
INFORMATION WARFARE APPLICATIONS COURSE	33	3-Aug-03	8-Aug-03	31
AF JROTC ACADEMIC INSTRUC	33	10-Aug-03	22-Aug-03	73
WING CHAPLAIN COURSE	33	7-Sep-03	20-Sep-03	32
USAFR FIRST SERGEANT ACAD.	32	20-Oct-02	2-Nov-02	30
EMPLOYEE DEVELOPMENT SPECIALIST COURSE	32	27-Oct-02	2-Nov-02	45
MISSION SUPPORT SQUADRON LEADERSHIP	32	17-Nov-02	22-Nov-02	16
CHAPLAIN PROFESSIONAL CONTINUING EDUCATION	32	18-Nov-02	22-Nov-02	25
SYSTEM MANAGERS COURSE	32	9-Dec-02	13-Dec-02	30
CHAPLAIN PROFESSIONAL CONTINUING EDUCATION	32	16-Dec-02	20-Dec-02	25
MILITARY PERSONNEL FLIGHT LEADERSHIP	32	5-Jan-03	10-Jan-03	15
USAFR FIRST SERGEANT ACAD.	32	5-Jan-03	18-Jan-03	20
CHAPLAIN PROFESSIONAL CONTINUING EDUCATION	32	6-Jan-03	10-Jan-03	25
MISSION SUPPORT SQUADRON LEADERSHIP	32	23-Feb-03	28-Feb-03	20
CHAPLAIN PROFESSIONAL CONTINUING EDUCATION	32	24-Feb-03	28-Feb-03	27
USAFR FIRST SERGEANT ACAD.	32	9-Mar-03	22-Mar-03	20
MILITARY PERSONNEL FLIGHT LEADERSHIP	32	6-Apr-03	11-Apr-03	24
ADVANCED TRIAL ADVOCACY	32	13-Apr-03	18-Apr-03	32
INSTALLATION MANPOWER	32	20-Apr-03	26-Apr-03	25

CHIEF COURSE				
CHAPLAIN PROFESSIONAL CONTINUING EDUCATION	32	19-May-03	23-May-03	28
USAFR FIRST SERGEANT ACAD.	32	1-Jun-03	14-Jun-03	20
MISSION SUPPORT SQUADRON LEADERSHIP	32	15-Jun-03	20-Jun-03	24
USAFR FIRST SERGEANT ACAD.	32	15-Jun-03	21-Jun-03	20
CHAPLAIN PROFESSIONAL CONTINUING EDUCATION	32	7-Jul-03	11-Jul-03	27
MILITARY PERSONNEL FLIGHT LEADERSHIP	32	20-Jul-03	25-Jul-03	19
EMPLOYEE DEVELOPMENT ADVANCED COURSE	32	24-Aug-03	29-Aug-03	44
MISSION SUPPORT SQUADRON LEADERSHIP	32	24-Aug-03	29-Aug-03	23
CHAPLAIN PROFESSIONAL CONTINUING EDUCATION	32	25-Aug-03	29-Aug-03	28
INSTALLATION MANPOWER CHIEF COURSE	32	7-Sep-03	13-Sep-03	25
SYSTEM MANAGERS COURSE	32	15-Sep-03	19-Sep-03	40
MILITARY PERSONNEL FLIGHT LEADERSHIP	32	21-Sep-03	26-Sep-03	21
USAFR FIRST SERGEANT ACAD.	32	21-Sep-03	1-Oct-03	20
CHAPLAIN PROFESSIONAL CONTINUING EDUCATION	32	22-Sep-03	26-Sep-03	24
ENLISTED PROFESSIONAL EDUCATION INSTRUCTOR	31	5-Oct-02	12-Oct-02	19
AFIADL COURSE FOR AUTHORS	31	20-Oct-02	26-Oct-02	18
ENLISTED PROFESSIONAL EDUCATION INSTRUCTOR	31	16-Nov-02	23-Nov-02	23
FAMILY SUPPORT CENTER MANAGER QUALIFICATION	31	8-Dec-02	14-Dec-02	21
FSC FAMILY READINESS QUALIFICATION COURSE	31	26-Jan-03	31-Jan-03	24
AFIADL COURSE FOR AUTHORS	31	2-Feb-03	8-Feb-03	18

ENLISTED PROFESSIONAL EDUCATION INSTRUCTOR	31	3-Feb-03	4-Feb-03	20
ENLISTED PROFESSIONAL EDUCATION INSTRUCTOR	31	10-Mar-03	11-Mar-03	19
FAMILY SUPPORT CENTER MANAGER QUALIFICATION	31	6-Apr-03	11-Apr-03	19
ENLISTED PROFESSIONAL EDUCATION INSTRUCTOR	31	25-Apr-03	30-Apr-03	19
AFIADL COURSE FOR AUTHORS	31	4-May-03	10-May-03	18
FAMILY SUPPORT CENTER MANAGER QUALIFICATION	31	11-May-03	16-May-03	21
ENLISTED PROFESSIONAL EDUCATION INSTRUCTOR	31	27-Jun-03	2-Jul-03	15
FAMILY SUPPORT CENTER MANAGER QUALIFICATION	31	24-Aug-03	29-Aug-03	24
ENLISTED PROFESSIONAL EDUCATION INSTRUCTOR	31	29-Aug-03	4-Sep-03	10
FSC FAMILY READINESS QUALIFICATION COURSE	31	14-Sep-03	19-Sep-03	24
ON-SCENE COMMANDERS	30	20-Oct-02	25-Oct-02	17
ON-SCENE COMMANDERS	30	3-Nov-02	8-Nov-02	17
ON-SCENE COMMANDERS	30	1-Dec-02	6-Dec-02	17
ON-SCENE COMMANDERS	30	5-Jan-03	10-Jan-03	17
AFIT ACADEMIC INSTRUCTOR	30	12-Jan-03	31-Jan-03	8
ON-SCENE COMMANDERS	30	27-Jan-03	1-Feb-03	17
ON-SCENE COMMANDERS	30	30-Mar-03	4-Apr-03	17
AFIT ACADEMIC INSTRUCTOR	30	6-Apr-03	25-Apr-03	10
ON-SCENE COMMANDERS	30	6-Apr-03	11-Apr-03	17
INFORMATION OPERATIONS LAW COURSE	30	27-Apr-03	2-May-03	77
LEGAL ASPECTS OF INFORMATION OPERATIONS	30	28-Apr-03	1-May-03	40
ON-SCENE COMMANDERS	30	5-May-03	9-May-03	17
ON-SCENE COMMANDERS	30	18-May-03	23-May-03	17

AFIT ACADEMIC INSTRUCTOR	30	1-Jun-03	20-Jun-03	10
ON-SCENE COMMANDERS	30	1-Jun-03	6-Jun-03	19
ON-SCENE COMMANDERS	30	9-Jun-03	14-Jun-03	19
INTERNATIONAL LAW COURSE	30	10-Jun-03	14-Jun-03	42
ON-SCENE COMMANDERS	30	6-Jul-03	11-Jul-03	17
ON-SCENE COMMANDERS	30	14-Jul-03	19-Jul-03	17
ON-SCENE COMMANDERS	30	10-Aug-03	15-Aug-03	17
ON-SCENE COMMANDERS	30	24-Aug-03	29-Aug-03	17
AFIT ACADEMIC INSTRUCTOR	30	7-Sep-03	26-Sep-03	15
HISTORIAN CRAFTSMAN	29	20-Oct-02	2-Nov-02	8
READINESS CHAPLAIN COURSE	29	31-Oct-02	1-Nov-02	2
HISTORIAN CRAFTSMAN	29	3-Nov-02	19-Nov-02	8
READINESS CHAPLAIN COURSE	29	6-Feb-03	15-Feb-03	2
HISTORIAN CRAFTSMAN	29	2-Mar-03	15-Mar-03	9
HISTORIAN CRAFTSMAN	29	3-Aug-03	16-Aug-03	9
CAREER SERVICE OFFICER WORKSHOP	25	2-Jun-03	5-Jun-03	25
MONTGOMERY RETIRED MILITARY GOLF TOURN.	22	15-Jun-03	20-Jun-03	300
CAP SE REGION CHAPLAIN STAFF COLLEGE	20	28-Apr-03	2-May-03	80
AU GUARD, RESERVE AND CIVILIAN AY04	20	9-Jun-03	13-Jun-03	82
CADET OFFICER SCHOOL	20	21-Jun-03	30-Jun-03	129
CAP SE REGION CHAPLAIN STAFF COLLEGE	20	17-Sep-03	28-Sep-03	152
AEROSPACE SCIENCE INSTR COURSE (ASIC)	18	13-Jul-03	17-Jul-03	60
ASIC AEROSPACE SCIENCE INST COURSE LONG COURSE	18	13-Jul-03	26-Jul-03	85
AEROSPACE SCIENCE INSTR COURSE (ASIC)	18	10-Aug-03	15-Aug-03	46
ASIC AEROSPACE SCIENCE	18	10-Aug-03	23-Aug-03	50

INST COURSE LONG COURSE				
AWC JUMP START	17	1-Mar-03	7-Mar-03	45
AWC JUMP START	17	8-Mar-03	19-Mar-03	45
AWC JUMP START	17	2-Jun-03	13-Jun-03	60
AWC JUMP START	17	15-Jun-03	27-Jun-03	60
AWC JUMP START	17	12-Jul-03	18-Jul-03	45
MICROBAS TRAINING CLASS	16	21-Oct-02	25-Oct-02	16
AIRCRAFT MAINTENANCE CHIEF ADVISORY BOARD	16	13-Jan-03	18-Jan-03	35
MICROBAS TRAINING CLASS	16	20-Jan-03	24-Jan-03	10
SAASS WARGAMES002	16	23-Feb-03	1-Mar-03	18
BEGINNING WEBMASTER CLASS (HTML)	16	23-Feb-03	28-Feb-03	21
MICROBAS TRAINING CLASS	16	17-Mar-03	21-Mar-03	8
AF SNCOA GRADUATION CEREMONY NAF CCMS	16	20-Apr-03	25-Apr-03	15
AF SNCOA GRADUATION CEREMONY NAF CCMS	16	20-Apr-03	25-Apr-03	15
AEROSPACEX	16	18-May-03	31-May-03	15
MICROBAS TRAINING CLASS	16	18-May-03	23-May-03	7
EMPLOYEE MANAGEMENT RELATIONS COURSE WORKSHOP	16	8-Jun-03	27-Jun-03	6
AF SNCOA GRADUATION CEREMONY NAF CCMS	16	15-Jun-03	19-Jun-03	15
BEGINNING WEBMASTER CLASS (HTML)	16	13-Jul-03	18-Jul-03	19
MICROBAS TRAINING CLASS	16	14-Jul-03	18-Jul-03	4
MICROBAS TRAINING CLASS	16	11-Aug-03	15-Aug-03	12
AF SNCOA GRADUATION CEREMONY NAF CCMS	16	2-Sep-03	5-Sep-03	15
PRINCIPLES OF AFFIRMATIVE EMPLOYMENT COURSE WORKSHOP	15	4-Mar-03	21-Mar-03	5

ADVANCED POSITION CLASSIFICATION COURSE WORKSHOP	15	23-Mar-03	10-Apr-03	4
AFDWG, AIR FORCE DOCTRINE WORKING GROUP	15	7-Apr-03	9-Apr-03	32
LABOAR RELATIONS COURSE WORKSHOP	15	5-May-03	23-May-03	6
AFFIRMATIVE EMPLOYMENT ADVANCED COURSE	15	7-Jul-03	25-Jul-03	6
INTERMEDIATE POSITION CLASSIFICATION COURSE	15	27-Jul-03	15-Aug-03	6
AF INFORMATION TECHNOLOGY CONFERENCE	15	24-Aug-03	28-Aug-03	20
AFDWG, AIR FORCE DOCTRINE WORKING GROUP	15	8-Sep-03	10-Sep-03	35
SYSTEM MANAGERS COURSE WORKSHOP	14	1-Dec-02	13-Dec-02	30
EMPLOYEE MANAGEMENT RELATIONS ADVANCED	14	21-Jan-03	6-Feb-03	6
EEO MANAGERS COURSE	14	18-Feb-03	28-Feb-03	6
CCAF BOARD OF VISITORS	14	13-Apr-03	16-Apr-03	15
BASIC MEDIATION WORKSHOP	14	26-May-03	6-Jun-03	4
EMPLOYEE DEVELOPMENT ADVANCED COURSE	14	18-Aug-03	26-Aug-03	4
SYSTEM MANAGERS COURSE	14	9-Sep-03	26-Sep-03	6
SYSTEM MANAGERS COURSE	14	14-Sep-03	26-Sep-03	6
EXECUTIVE TECHNOLOGY COURSE	14	24-Sep-03	26-Sep-03	14
ARMY RECRUITING STATION COMMANDER	13	6-Dec-02	7-Dec-02	35
MONTGOMERY RECRUITING COMPANY LEADERSHIP MEETING	13	1-Apr-03	2-Apr-03	12
ARMY RECRUITING MASTER SERGEANT NCOPD	12	9-Oct-02	10-Oct-02	12
ARMY RECRUITING MASTER	12	5-Mar-03	6-Mar-03	7

SERGEANT NCOPD				
NCOA GRADUATION	12	25-Mar-03	28-Mar-03	10
NCOA GRADUATION	12	13-May-03	16-May-03	10
NCOA GRADUATION	12	29-Jun-03	2-Jul-03	10
NCOA GRADUATION	12	7-Sep-03	10-Sep-03	10
ROTC FIELD TRAINING PRE PLANNING CONFERENCE	11	9-Feb-03	14-Feb-03	112
908AW UTA TRAINING	10	4-Oct-02	6-Oct-02	350
187 TFG UTA TRAINING	10	18-Oct-02	20-Oct-02	40
187 TFG UTA OR OTHER TRAINING	10	28-Oct-02	1-Nov-02	40
908AW UTA OR OTHER GROUP TRAINING	10	1-Nov-02	3-Nov-02	300
187 TFG UTA OR OTHER TRAINING	10	1-Nov-02	3-Nov-02	150
908AW UTA OR OTHER GROUP TRAINING	10	2-Nov-02	3-Nov-02	50
908AW UTA OR OTHER GROUP TRAINING	10	10-Jan-03	12-Jan-03	350
187 TFG UTA OR OTHER TRAINING	10	10-Jan-03	12-Jan-03	150
187 TFG UTA OR OTHER TRAINING	10	7-Feb-03	9-Feb-03	150
908AW UTA OR OTHER GROUP TRAINING	10	7-Mar-03	8-Mar-03	300
187 TFG UTA OR OTHER TRAINING	10	7-Mar-03	9-Mar-03	150
908AW UTA OR OTHER GROUP TRAINING	10	8-Mar-03	9-Mar-03	50
187 TFG UTA OR OTHER TRAINING	10	14-Mar-03	16-Mar-03	40
908AW UTA OR OTHER GROUP TRAINING	10	4-Apr-03	6-Apr-03	300
908AW UTA OR OTHER GROUP TRAINING	10	4-Apr-03	6-Apr-03	50
187 TFG UTA OR OTHER	10	11-Apr-03	13-Apr-03	150

TRAINING				
908AW UTA OR OTHER GROUP TRAINING	10	2-May-03	4-May-03	300
187 TFG UTA OR OTHER TRAINING	10	16-May-03	18-May-03	40
908AW UTA OR OTHER GROUP TRAINING	10	6-Jun-03	8-Jun-03	300
187 TFG UTA OR OTHER TRAINING	10	6-Jun-03	8-Jun-03	150
908AW UTA OR OTHER GROUP TRAINING	10	7-Jun-03	8-Jun-03	50
AFMC COMMAND CHIEFS FIRST SERGEANTS CONFERENCE	10	23-Jun-03	27-Jun-03	85
908AW UTA OR OTHER GROUP TRAINING	10	11-Jul-03	13-Jul-03	300
187 TFG UTA OR OTHER TRAINING	10	11-Jul-03	13-Jul-03	150
908AW UTA OR OTHER GROUP TRAINING	10	12-Jul-03	13-Jul-03	50
AETC GOLF CHAMPIONSHIP	10	13-Jul-03	18-Jul-03	75
187 TFG UTA OR OTHER TRAINING	10	25-Jul-03	27-Jul-03	40
908AW UTA OR OTHER GROUP TRAINING	10	8-Aug-03	10-Aug-03	300
187 TFG UTA OR OTHER TRAINING	10	8-Aug-03	10-Aug-03	150
908AW UTA OR OTHER GROUP TRAINING	10	9-Aug-03	10-Aug-03	50
187 TFG UTA OR OTHER TRAINING	10	22-Aug-03	24-Aug-03	40
187 TFG UTA OR OTHER TRAINING	10	19-Sep-03	21-Sep-03	150
SOLO CHALLENGE	9	27-Apr-03	9-May-03	30
7TH BN/100TH INF DIV	9	18-Sep-03	21-Sep-03	80
7TH BN, 100TH DIV	8	12-Oct-02	13-Oct-02	50
AFPEO EXECUTION MEETING	8	4-Nov-02	6-Nov-02	51

ARMS SEERING GROUP	8	17-Nov-02	23-Nov-02	29
ARMS STEERING GROUP	8	18-Nov-02	22-Nov-02	29
RECRUITING PARTNERSHIP MEETING	8	9-Jan-03	11-Jan-03	55
DEFENSE MEDICAL READINESS TRAINING	8	22-Jan-03	27-Jan-03	15
JROTC VISIT:	8	30-Jan-03	2-Feb-03	48
JROTC VISIT:	8	31-Jan-03	1-Feb-03	48
JROTC VISIT:	8	31-Jan-03	2-Feb-03	4
NCO ACADEMY COMMANDANTS CONF.	8	3-Feb-03	7-Feb-03	11
CEPME AWARDS BANQUET	8	4-Feb-03	7-Feb-03	50
JROTC VISIT:	8	14-Feb-03	15-Feb-03	30
HMM 266 JACKSONVILLE NC	8	24-Feb-03	28-Feb-03	12
JROTC VISIT:	8	13-Mar-03	15-Mar-03	55
HMM-266 NEW RIVER	8	2-Apr-03	3-Apr-03	60
JROTC VISIT:	8	4-Apr-03	5-Apr-03	30
AFROTC SE REGION TRAINING CONFERENCE	8	7-Apr-03	10-Apr-03	70
ORACLE II 1	8	26-May-03	11-Jun-03	5
ORACLE II 1	8	1-Jun-03	4-Jun-03	37
ORACLE II 1	8	4-Jun-03	7-Jun-03	42
ORACLE II 1	8	8-Jun-03	11-Jun-03	38
CHAPLAIN CANDIDATE COURSE	8	15-Jun-03	28-Jun-03	25
CHAPLAIN CANDIDATE COURSE	8	6-Jul-03	19-Jul-03	30
ESOHCAMP 2003	8	24-Aug-03	29-Aug-03	28
NAVY RECRUITING DISTRICT CHANGE OF COMMAND	8	3-Sep-03	4-Sep-03	23
AFROTC SE REGION COMMANDT OF CADET CONFERENCE	8	23-Sep-03	26-Sep-03	40
NAVY RECRUITING DISTRICT,	7	24-Oct-02	25-Oct-02	45

PHYSICAL FITNESS ASSESS.				
AETC IT CONFERENCE	7	18-Nov-02	22-Nov-02	25
REPRTS WORKING GROUP AND CONOPS WORKING GROUP	7	5-Jan-03	25-Jan-03	19
NAVY RECRUITING DISTRICT, PHYSICAL FITNESS ASSESS.	7	3-Apr-03	4-Apr-03	44
AF COURT/BOARD REPORTERS TRAINING	7	13-Apr-03	19-Apr-03	21
HOUSING PRIVATIZATION WORKSHOP	7	27-May-03	30-May-03	50
FOREST POST WORKING GRP	7	4-Aug-03	8-Aug-03	25
ACES REAL PROPERTY IPT	7	11-Aug-03	15-Aug-03	30
ROTC RDA CONFERENCE	7	17-Aug-03	21-Aug-03	25
ENTERPRISE ARCHITECTURE PROCUREMENT TEAM	7	17-Aug-03	29-Aug-03	12
HIGH SCHOOL OR YOUTH GROUP VISIT OR TOUR	6	1-Oct-02	2-Oct-02	58
1387TH QUARTERMASTER	6	11-Oct-02	13-Oct-02	30
SECURITY FORCES MGMT INFORMATION TRAINING	6	13-Oct-02	19-Oct-02	24
CCAF WORKSHOP	6	27-Oct-02	1-Nov-02	18
NCO ACADEMY ED CONF.	6	4-Nov-02	8-Nov-02	20
SECURITY FORCES MGMT INFORMATION TRAINING	6	17-Nov-02	22-Nov-02	20
USAF SUPERVISOR COURSE	6	12-Jan-03	18-Jan-03	15
HIGH SCHOOL OR YOUTH GROUP VISIT OR TOUR	6	16-Jan-03	19-Jan-03	20
SECURITY FORCES MGMT INFORMATION TRAINING	6	26-Jan-03	1-Feb-03	20
EGLIN PUPPETRY MINISTRY	6	7-Feb-03	9-Feb-03	25
SECURITY FORCES MGMT INFORMATION TRAINING	6	9-Feb-03	14-Feb-03	20
SECURITY FORCES MGMT INFORMATION TRAINING	6	17-Feb-03	21-Feb-03	20

SUPPLY X2 CONFERENCE	6	18-Feb-03	21-Feb-03	42
SECURITY FORCES MGMT INFORMATION TRAINING	6	23-Feb-03	28-Feb-03	20
SECURITY FORCES MGMT INFORMATION TRAINING	6	3-Mar-03	7-Mar-03	25
HIGH SCHOOL OR YOUTH GROUP VISIT OR TOUR	6	6-Mar-03	9-Mar-03	70
HIGH SCHOOL OR YOUTH GROUP VISIT OR TOUR	6	7-Mar-03	9-Mar-03	28
HIGH SCHOOL OR YOUTH GROUP VISIT OR TOUR	6	7-Mar-03	8-Mar-03	27
ADVANCED CAMS DATABASE MANAGERS WORKSHOP	6	17-Mar-03	28-Mar-03	14
HIGH SCHOOL OR YOUTH GROUP VISIT OR TOUR	6	16-Apr-03	18-Apr-03	18
HIGH SCHOOL OR YOUTH GROUP VISIT OR TOUR	6	16-Apr-03	18-Apr-03	28
SECURITY FORCES MGMT INFORMATION TRAINING	6	4-May-03	10-May-03	10
CCAF WORKSHOP	6	12-May-03	17-May-03	20
OLVIMS OPERATIONAL ARCHECTURE	6	27-May-03	12-Jul-03	10
MRD RECRIOTER IN CHARGE TRAINING	6	1-Jun-03	2-Jun-03	30
AWC ACSC ORIENTATION ANG	6	9-Jun-03	13-Jun-03	24
ADVANCED CAMS DATABASE MANAGERS WORKSHOP	6	13-Jul-03	25-Jul-03	14
SECURITY FORCES MGMT INFORMATION TRAINING	6	10-Aug-03	16-Aug-03	16
SECURITY FORCES MGMT INFORMATION TRAINING	6	10-Aug-03	16-Aug-03	16
CCAF WORKSHOP	6	25-Aug-03	30-Aug-03	20
ASBC WORKSHOP	6	26-Aug-03	29-Aug-03	25
AU ORIENTATION	6	3-Sep-03	6-Sep-03	31
AU ORIENTATION	6	10-Sep-03	12-Sep-03	27
LEGAL ASPECTS OF SEXUAL	6	21-Sep-03	23-Sep-03	50

ASSUALT WORKSHOP				
WEDDING:	5	1-Nov-02	3-Nov-02	12
WEDDING:	5	24-Dec-02	30-Dec-02	25
WEDDING:	5	9-May-03	11-May-03	15
WEDDING:	5	21-Jun-03	22-Jun-03	12
WEDDING:	5	26-Jun-03	30-Jun-03	15
WEDDING:	5	31-Jul-03	2-Aug-03	8
WEDDING:	5	8-Aug-03	10-Aug-03	25
EDUCATION SERVICES ADVISORY PANEL	5	11-Aug-03	17-Aug-03	19
ALABAMA ARMY GUARD CHAPLAIN CONFERENCE	5	22-Sep-03	23-Sep-03	22
RETIREMENT CEREMONY	4	3-Oct-02	7-Oct-02	8
LOGMOD TRAINING CLASS	4	27-Oct-02	9-Nov-02	12
CIVIL ENGINEER TEAM, RANDOLPH	4	12-Nov-02	22-Nov-02	9
913TH AIR WING	4	22-Nov-02	23-Nov-02	20
LOGMOD TRAINING CLASS	4	26-Jan-03	8-Feb-03	16
ARMY RECRUITING ROCKWALL TRAINING	4	27-Jan-03	30-Jan-03	15
EXECUTIVE TECHNOLOGY	4	28-Jan-03	31-Jan-03	8
EDUCATION INTEGRATED PRODUCT TEAM	4	18-Feb-03	21-Feb-03	15
LOGMOD TRAINING CLASS	4	23-Feb-03	7-Mar-03	15
RETIREMENT CEREMONY	4	3-Mar-03	8-Mar-03	15
LOGMOD TRAINING CLASS	4	16-Mar-03	28-Mar-03	15
RETIREMENT CEREMONY	4	27-Mar-03	28-Mar-03	10
LOGMOD TRAINING CLASS	4	6-Apr-03	18-Apr-03	16
HIGH SCOPE CHILD DEVELOPMENT CONF.	4	9-Apr-03	12-Apr-03	16
LOGMOD TRAINING CLASS	4	1-Jun-03	13-Jun-03	15
LOGMOD TRAINING CLASS	4	6-Jul-03	18-Jul-03	16
FAA LEADERSHIP AND	4	21-Jul-03	26-Jul-03	40

MANAGERS TEAM MEETING				
LOGMOD TRAINING CLASS	4	27-Jul-03	8-Aug-03	16
100TH DIV INSPECTION	4	9-Aug-03	10-Aug-03	15
LOGMOD TRAINING CLASS	4	17-Aug-03	29-Aug-03	13
RETIREMENT CEREMONY	4	28-Aug-03	30-Aug-03	5
LOGMOD TRAINING CLASS	4	7-Sep-03	19-Sep-03	12
50TH FTS, COLUMBUS AFB	3	18-Oct-02	20-Oct-02	13
HOWARD CLARK FAMILY	3	27-Nov-02	1-Dec-02	8
ARMY RECRUITING LEADERSHIP TEAMS	3	27-Jan-03	28-Jan-03	10
48TH FTS LAYOVER	3	21-Feb-03	23-Feb-03	12
331ST RECRUITING SQDN	3	26-Feb-03	28-Feb-03	20
EGLIN SOCCER TEAM	3	15-Mar-03	16-Mar-03	12
48TH FTS LAYOVER	3	24-Mar-03	27-Mar-03	14
INTERNAL CONTROL ASSISTANCE ICAM CONF.	3	27-Apr-03	30-Apr-03	8
LT COL DEAN FOWLER GRADUATION	3	19-May-03	21-May-03	10
FM CC SEMINAR	3	16-Jun-03	20-Jun-03	11
SENR PARALEGAL MANAGERS	3	19-Jun-03	22-Jun-03	11
AL ESGR ANNUAL MEETING	3	20-Jun-03	22-Jun-03	20
48TH FTS LAYOVER	3	21-Jun-03	22-Jun-03	12
FM CC SEMINAR	3	7-Jul-03	11-Jul-03	15
GEN BARNES GOLF TOURN.	3	9-Jul-03	10-Jul-03	20
BLACKS IN GOV. MEETING	3	1-Aug-03	3-Aug-03	14
AETC SSO SSR CONFERENCE	3	6-Aug-03	8-Aug-03	10
HIGH SCOPE TRAINING	3	25-Aug-03	29-Aug-03	15
OARS TRAINING	2	18-Feb-03	20-Feb-03	9
DLA STRESS MANAGEMENT	2	21-Mar-03	22-Mar-03	7
OARS TRAINING	2	19-May-03	21-May-03	2
JOINT RELIGIOUS AFFAIRS WORKING GROUP	2	27-May-03	30-May-03	10

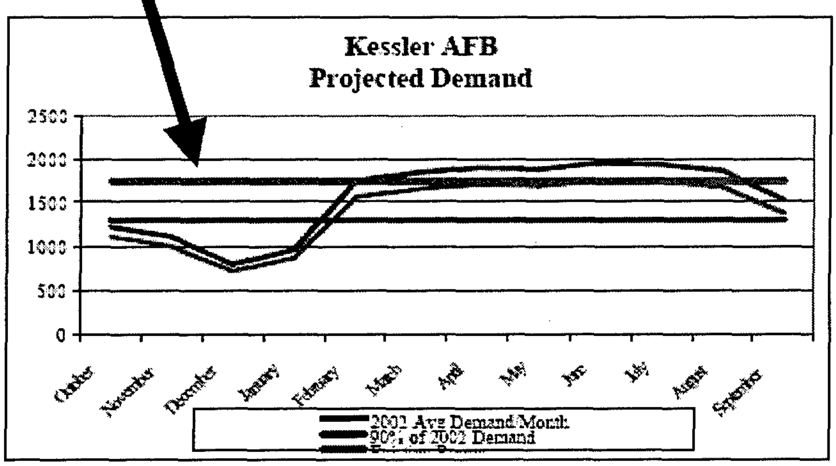
AU GERMAN EXHIBITION	2	10-Sep-03	11-Sep-03	7
COL MERCER RETIREMENT	2	29-Sep-03	1-Oct-03	10
EMPLOYEE DEVELOPMENT SPECIALIST COURSE	0	20-Oct-02	1-Nov-02	6

APPENDIX B. KEESLER AFB NEEDS ASSESSMENT

Chapter 3 argued that the methodology employed by the Keesler AFB needs assessment underestimated the number of contract quarters for the assumed demand pattern. Figures B.1 and B.2 are screenshots from the draft needs assessment, highlighting some of the methodological issues discussed in Chapter 3.

Projected Utilization

As discussed in the Historical Analysis section, Priority One demand in 2002 was higher than in any other recent year. A comparison of 2002 and 2003 year-to-date indicates the 2003 demand on monthly basis is equal to that achieved in 2002. In 2002, there was a total Priority One demand of 570,000 room nights or an average of 1,562 room nights per day. The average demand from 1998 through 2001 was 1,350 room nights per day. The increase in demand is attributable to an increased student load. The Air Force standard for construction is to build sufficient units to meet 90% of demand. If it is assumed that the demand in 2002 is indicative of future demand, to meet this standard, a total of 1,750 rooms are required, but the resulting occupancy rate would be approximately 80%. The graph below compares the 2002 demand to the existing room inventory and that required to meet 90% of the Priority One lodging demand.



In addition to the demand documented in 2002, several class additions in 2004 will further increase the potential demand from students. Three new courses that occur three to four times each per year have been funded and will begin in 2004. These courses will each have 16 to 30 students will run 45 to 90 days. A total of 14,400 room nights are expected to be needed to accommodate these students. Only one of these class sessions is expected to occur during a period when lodging has the capacity to house these personnel on base. During the other nine sessions, the students will most

Visitors Quarters at Kessler AFB
Evans & Chastain, L.L.P. with
Architecture, Inc.
June 2003 - Draft

Page K-1

Figure B.1 – Screenshot of Page K-1, Keesler Needs Assessment

Proposed Scope of Operations Perspective

likely be sent off base for approximately 13,500 room nights. This additional demand equates to approximately 30 additional rooms to meet the 90% of demand criteria, increasing the total number of rooms needed from 1,750 rooms to 1,780 rooms.

It can be clearly seen that the installation has need for more than the number of rooms it currently has, but probably not the 476 incremental rooms needed to meet 90% of the priority one demand. The commercial market off base is extensive and intense. This high level of competition has kept the contract rates charged to the installation in the range of $45 to $55 per night. An analysis of the sensitivity of the demand suggests that 1,458 rooms will equalize the cost of off base lodging with the cost of building and maintaining vacant rooms. This number of rooms will allow lodging to meet more than 80% of the Priority One demand annually.

FY02 Contract Quarters were $13 million and FY03 totals were nearly $16 million.

The graph below presents the combined cost of building and operating vacant rooms and the cost of off base lodging. At the existing inventory level, it is estimated that over $6,400,000 will be paid to off base contract hotels annually. Approximately $1,600,000 of this cost is avoided by not building additional rooms. Unfortunately, less than 70% of the Priority One demand will be accommodated on base. If 1,458 rooms were built, then the cost of the vacant rooms would approximate the cost of the room nights sent off base. The total cost of the room nights sent off base should approximate $4,500,000. As the number of rooms is increased to the number needed to meet 90% of the Priority One demand, the incremental cost of the vacant rooms increases and the cost of the room nights sent off base decreases. But on a combined basis they approximate the $4,500,000 incurred for off base lodging with 1,458 rooms. Thus, by increasing the number of rooms to be built above 1,458, no additional money is saved. It is merely shifted to construction and operating costs.

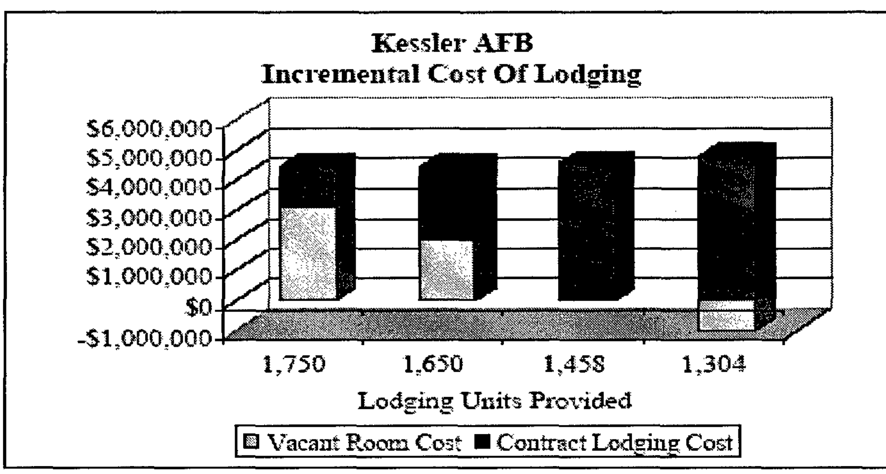


Figure B.2 – Screenshot of Page K-2, Keesler Needs Assessment

While the needs assessment does not explicitly describe the methodology for determining which demands are placed on-base and which require contract quarters, we have made inferences from the report charts, figures, and calculations. Figure B.1 highlights concern with how contract quarters and occupancy rates were determined from excess-demand measures. For example, the capacity level to house 90 percent of demands on-base appears to be determined by calculating 90 percent of the monthly-demand averages and then finding the maximum in this series, 1,750 in June. This methodology is unlikely to result in 90 percent of the year's priority-one demand being housed on-base because (1) it selects a capacity based on 90 percent of the peak-demand month, not 90 percent of the year's priority-one average, (2) it uses monthly averages for demand, and (3) it assumes that demands less than supply will be housed on-base. A more detailed analysis of demand composition and the reservation placement decisions would be needed to project occupancy.

Figure B.2 illustrates the underestimate for annual contract-quarters costs. Actual costs are two to two and one-half times the assessment's estimate. We conclude that the $6.4 million estimates come from an oversimplified methodology that neglects the factors described in Chapter 3. This should raise doubts as to the efficacy of construction recommendations based on these estimates. While the Keesler needs assessment computation methodology is not delineated in the report, the estimates are equivalent to those calculated in Table B.1 using the following methodology:

- The current total spaces (1,304 rooms) are subtracted from the daily average demands by month to calculate excess demands. The excess-demand differences become the daily projections for the number of contract quarters in each month.
- These daily projections are then multiplied by the number of days per month and summed across the year to yield annual totals.
- The total number of projected contract quarters is then multiplied by the average contract-quarters cost to yield the annual-total-cost estimate.

Table B.1
Projected Contract Quarters at Keesler AFB, Based on Excess Demand and Monthly Data

Month	Average Daily Demand	On-Base Capacity	Daily Contract-Quarters Projections	Monthly Contract-Quarters Projections	Projected Contract-Quarters Cost ($)
Oct	1,250	1,304	-	-	0
Nov	1,125	1,304	-	-	0
Dec	800	1,304	-	-	0
Jan	950	1,304	-	-	0
Feb	1,750	1,304	446	12,488	624,400
Mar	1,850	1,304	546	16,926	846,300
Apr	1,925	1,304	621	18,630	931,500
May	1,900	1,304	596	18,476	923,800
Jun	1,975	1,304	671	20,130	1,006,500
Jul	1,950	1,304	646	20,026	1,001,300
Aug	1,875	1,304	571	17,701	885,050
Sep	1,525	1,304	221	6,630	331,500
Total			**4,318**	**131,007**	6,550,350

NOTES: The average daily demands are estimates from the Keesler needs assessment's chart (see Figure B.1 above). We did not have the data used in the assessment for this analysis. An average contract-quarters price of $50 was used to compute total costs. This price is consistent with the average price in FY02 ($50.88) and FY03 ($48.39). The price and demand estimates explain the slight difference between the projection in this table and the needs assessment's projection of "over $6.4 million."

APPENDIX C. STOCHASTIC POISSON ESTIMATES

C.1 METHODOLOGY

This appendix provides a more detailed discussion of the estimation of residual and space-available demand in Chapter 5. These demands were estimated using a linear model that predicts the square root of demand. The square root is the variance-stabilizing transform for Poisson observations. That is, the variance of the square root of a Poisson random variable is nearly constant. Therefore, the model for demand, S_i, is $\sqrt{S_i} = B'x + \varepsilon$ and $Var(\varepsilon) \approx \sigma^2$ when S_i is sufficiently large ($S_i > 15$).[187] The estimation methodology followed these steps:

1) Take the square root of the daily residual-demand data (Figure 5.3). These 365 observations formed the basis for estimating the linear parameters of the regression model.
2) Regress the square root derived in step 1 on significant (practically and statistically) covariates: course demand, month, and day of the week. The regression includes an AR(1) residual error term to account for autocorrelated demands between days. The AR(1) time-series model was chosen for simplicity, explained the majority of the autocorrelation, and was highly significant (test statistic >15). The estimated regression parameters are given in Table C.1.
3) Square-rooted daily demands can be predicted from the regression model ($\hat{y}$) and by generating error terms with the estimated variance ($Var(\varepsilon) \approx \sigma^2$). Squaring these estimates yields the approximately Poisson-distributed daily residual demands. Figure 5.4 shows that the model's predicted residual demands are a good estimate for the actual residual demands.

---

[187] McCullagh and Nelder, 1989.

Table C.1
Regression Output

Covariate	Coefficient	Std. Error	Z-stat	P > |z|
Course demand	-0.0059	0.00098	-5.96	0.000
October	6.067	2.699	2.25	0.025
November	8.187	3.123	2.62	0.009
January	3.247	2.369	1.37	0.170
February	10.427	3.075	3.39	0.001
March	10.642	3.588	2.97	0.003
April	9.885	3.526	2.80	0.005
May	7.858	2.998	2.62	0.009
June	3.229	2.992	1.08	0.281
July	.0549	3.726	0.01	0.988
August	4.948	3.369	1.47	0.142
September	0.853	2.823	0.30	0.763
Monday	-1.756	0.945	-1.86	0.063
Tuesday	-0.405	0.757	-0.53	0.593
Thursday	-1.446	0.819	-1.76	0.078
Friday	-5.934	0.977	-6.07	0.000
Saturday	-3.669	1.024	-3.58	0.000
Sunday	-4.474	1.029	-4.35	0.000
Constant	16.523	2.624	6.30	0.000
AR(1)	0.656	0.043	15.17	0.000
Sigma	4.324	0.152	28.48	0.000

NOTE: Dummy variables for December and Wednesday are automatically included in the constant and dropped from the regression.

C.2 ADJUSTMENTS FOR FY04

The FY04 residual demands (~60,000 annual bed spaces) were predicted from the FY03 data. FY04 demands were predicted from the FY03 data, because we did not have access to daily-occupancy data for FY04. This is a fine assumption, since the residual-demand categories (i.e., other TDYs and courses not registered in EMS) should be approximately the same between years. Once daily data are exportable from LTS, further research should be done on predicting residual demands from several years of data. This will yield a better model fit that is not dependent upon one year's data.

Using the FY03 data, the FY04 predictive model was then modified slightly to generalize and predict demands in any year. The difference between the models is that some of the individual covariates in the linear-regression model were removed from the FY04 model. EMS course demand and the day of the week are retained because their effects are likely to be consistent across years. The FY04 model eliminates the month variables as individual covariates, with the exception of December.[188] Monthly predictors are removed because the predicted residual demands should not be directly linked to the high- and low-residual-demand periods in the FY03 data. Periods of higher residual demand can occur when courses are not included in the EMS database, and low periods can occur when a listed course is canceled. The FY04 model should not enforce these high and low periods to occur within specific months (i.e., when they occurred in FY03), because they will occur at different times in different years.

In FY03, residual demands were high in November, February, and, to a lesser extent, May (Figure 5.3). Dropping the monthly covariates from the regression model allows these high-residual-demand periods to occur at other times throughout the year, rather than being constrained to occur during those three months. Once several years of LTS data becomes available, the regression model for residual demands should be reestimated with monthly covariates.

[188] December is retained because low December demand is consistent from year to year due to the Christmas holiday. It is not a one-year data phenomenon.

APPENDIX D. COST ESTIMATION

This appendix provides a detailed discussion of cost estimation, which was examined broadly in Chapter 5. To determine the efficient facility capacity, the inventory model solves for the least-cost room inventory of the proposed facility-construction options. The least-cost inventory will minimize total annual lodging costs, which include the cost of on-base facilities and off-base contract quarters. The total on-base cost includes the annual operating costs for on-base facilities, both appropriated and nonappropriated, and the capital cost of additional-facility construction.[189] We are interested how the cost of on-base lodging is affected by increased occupancy and new-facility construction. Conversely, off-base costs are a direct function of the per-unit contract cost and the number of generated off-base placements.

In total, the model calculates five separate cost categories: off-base contract-quarters costs, NAF operating costs, direct appropriated-funding costs, new-facility capital costs, and the outsourced civil-engineering contract that provides services to lodging facilities. (The methodology for estimating contract-quarters costs was presented in Section 5.4.1.) The last four categories are separate funding sources for constructing, operating, and maintaining the on-base lodging operation. Lodging's on-base cost function is spread across different organizations and funding sources, making it difficult to estimate a total on-base lodging cost. It is recommended that AETC/FM review the cost estimates to ensure that all relevant costs are included and the results are consistent with AETC estimates. This analysis collects historical cost data and estimates cost functions for each on-base cost category. Sections D.1 through D.4 describe the items included in each cost category and the estimation function used in this analysis. Where appropriate, charts and regression output showing how each cost was estimated are provided.

---

[189] Air Force lodging receives funding from both appropriated and nonappropriated sources. Air Force Instruction 65-106 governs the use of appropriated and nonappropriated funds.

D.1 NONAPPROPRIATED-FUND COSTS

The lodging operation maintains detailed monthly operating statements on the use of NAF in each funding category. These statements formed the basis for our cost estimation by major funding category: sales, personnel, support, material, entertainment and promotion, other operating expenses, amortized expendable equipment, depreciated heavy equipment, and facility depreciation. Nonoperating costs such as the Air Force assessment are not included in the analysis because they are transfer payments and do not represent an actual operational expenditure. The analysis includes 33 operating statements from October FY02 through June FY04. All monthly expenditures are converted to constant FY03 dollars, using the consumer price index.[190]

Again, we are interested in how on-base lodging costs are affected by occupancy and new-facility construction. First, each category's monthly costs are analyzed to separate fixed and marginal cost components. Fixed costs are those expenses that do not vary with on-base occupancy, whereas marginal costs are those that increase with occupancy. If monthly costs vary by occupancy, the relationship is estimated linearly with an ordinary-least-squares (OLS) regression. Second-order polynomials were tested to see if costs varied nonlinearly with occupancy, but none was statistically significant. Next, this analysis investigates whether cost increases are linked to newly constructed facilities beyond the marginal cost increases associated with the increased occupancy in those facilities.[191] To evaluate this hypothesis, the analysis compares the monthly expenditures before and after the opening of building 681 at Maxwell AFB in January 2004. Initially, the comparisons were made graphically, but the graphs do not control for the higher occupancy in months after the new facility opened. To eliminate the confounding effect of occupancy, we computed a multivariate regression controlling for both occupancy and a dummy variable for the new facility. Having only six months of

---

[190] Amortization and depreciation costs were not converted to real dollars because they do not represent actual cost outlays in a specific month. It is assumed that these amortizations already account for the time value of money.

[191] There may be other fixed costs associated with operating and maintaining a new facility that would not be captured through simply projecting the costs from the increased on-base occupancy.

data since the opening of building 681 restricts significant comparative conclusions, but some results can be produced.

D.1.1 Sales Profit

Sales incorporate the profit generated from selling drinks and snack food at the front desk, in suites, and at Gunter's lodging-operated mini-store. Unlike the other categories, sales represent revenue and reduce the overall government cost burden of running the lodging operation. Logically, sales will be linked to the number of on-base occupants, even though the relationship will be inexact. Figure D.1 shows the correlation between sales and occupancy. The linear function provides the best linear unbiased estimate for monthly sales profits.[192]

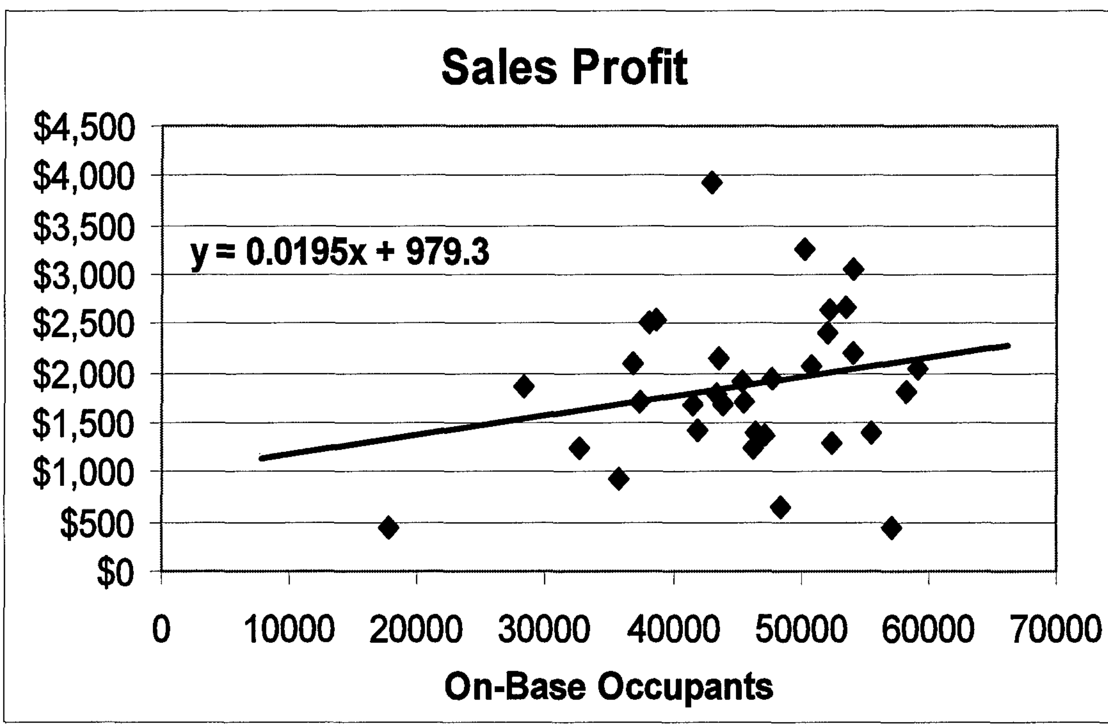


Figure D.1 – Monthly Sales Profit Versus Occupancy at Maxwell and Gunter

---

[192] OLS property.

There is no clear theoretical explanation for the effect of additional facilities construction on sales beyond the effect of additional on-base occupants. Figure D.2 confirms that hypothesis. Monthly sales profits were seemingly unaffected by the opening of building 681, even before controlling for the higher monthly occupancy in FY04.[193]

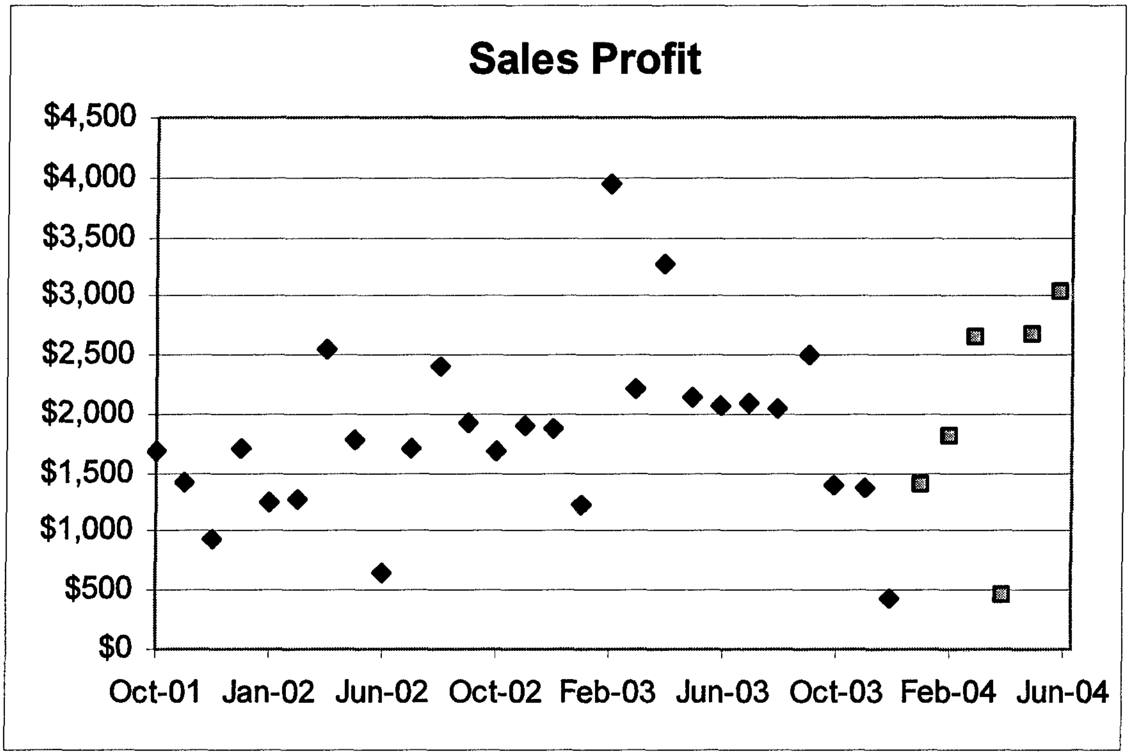


Figure D.2 – Monthly Sales Profit at Maxwell and Gunter

OLS estimates for monthly sales profits, which vary in occupancy but not with new-facility construction, are calculated as:

$$Sales = \$979.30 + \$.0194684 * Occupants$$

[193] The multivariate regression reveals no significant difference between monthly profits before and after the opening of the new SOC lodging facility. Multivariate-regression results are omitted from this section because Figure D.2 illustrates no effect.

D.1.2 Personnel Costs

Personnel costs comprise the payroll and benefit expenses of hiring the NAF employees to run the lodging operation. While the majority of the personnel are full-time, part-time and flex staff are utilized to meet the higher labor requirement during surge-occupancy periods. This flexibility allows labor expenses to vary with occupancy; in other businesses, labor expenses are typically fixed in the short run. Figure D.3 illustrates the correlation between personnel costs and occupancy.

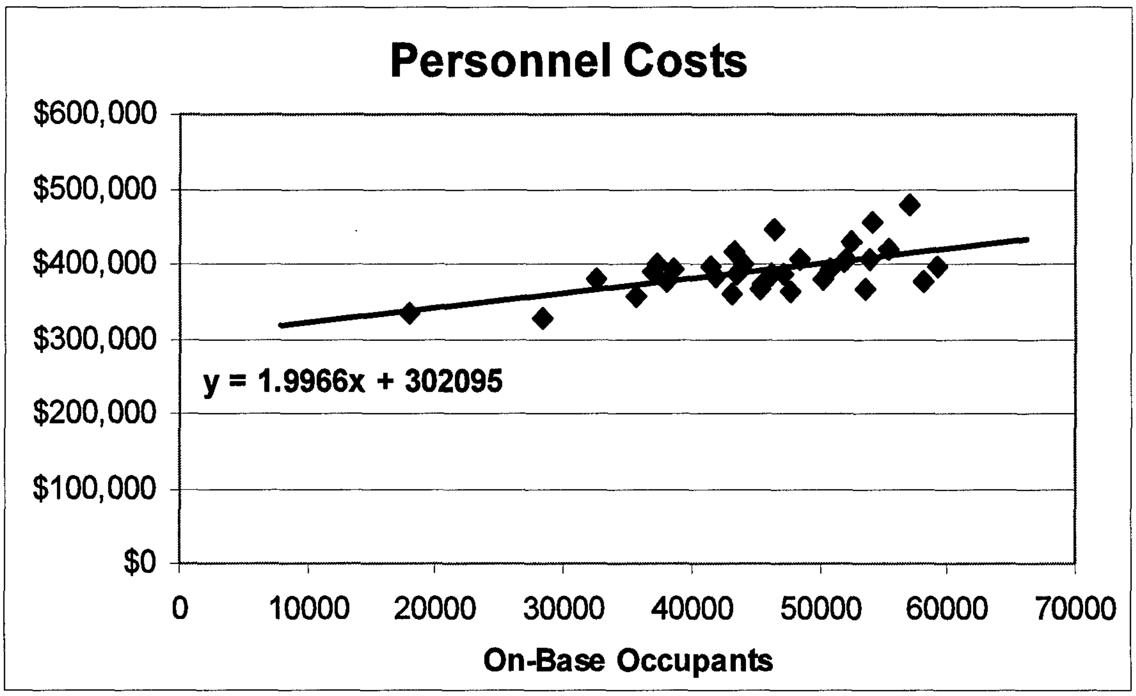


Figure D.3 – Monthly Personnel Costs at Maxwell and Gunter Versus Occupancy

Beyond the personnel needed to operate and maintain the new facility predicted by the marginal cost component, fixed personnel costs may be associated with the operation of a newly constructed facility. Figure D.4 indicates a small increase in monthly personnel costs after the opening of building 681. This suggests that additional full-time staff were hired for the new facility.

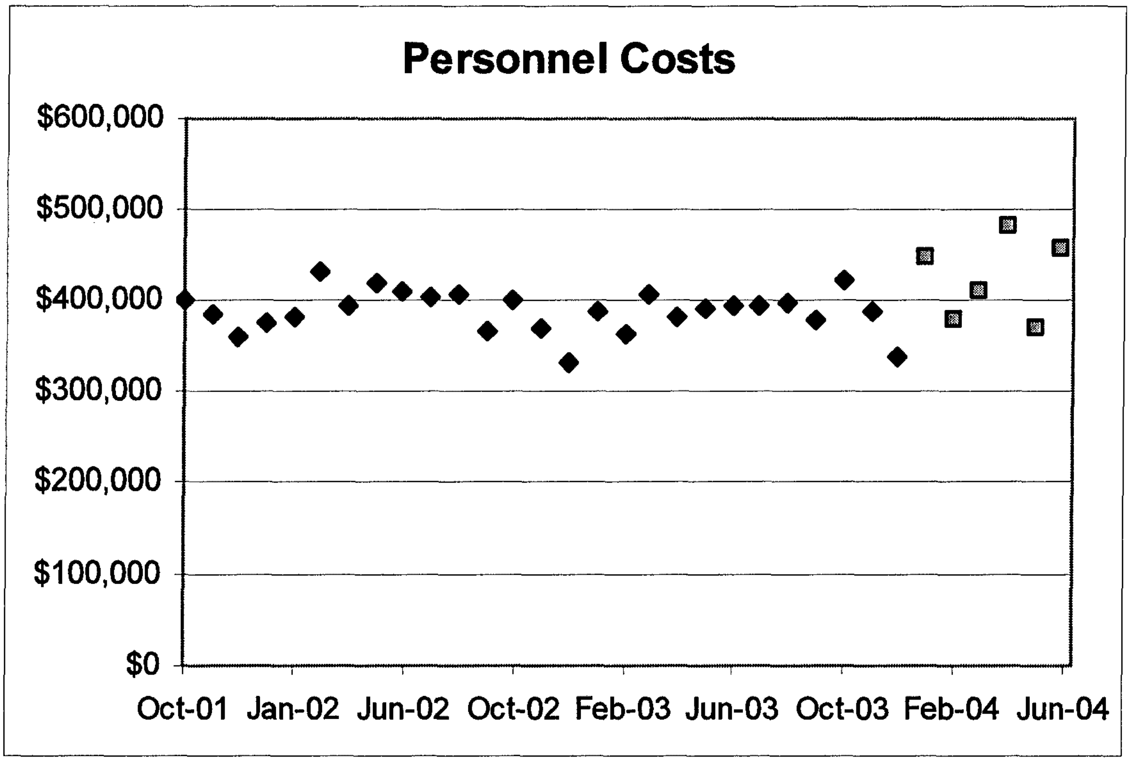


Figure D.4 – Monthly Personnel Costs Versus Time at Maxwell and Gunter

After controlling for the higher average occupancy in the months following the opening of building 681, the regression output reveals a mean increase of more than $19,000 per month. Although statistically insignificant due to the small number of data points and monthly variation, this is a meaningful increase and should be included. Table D.1 presents the multivariate-regression results.

Table D.1

Personnel Costs Regressed on Occupants and an SOC Dormitory Dummy Variable

Model Statistics	Value	ANOVA	Df	SS
Observations	33	Regression	2	1.186 E+10
R-squared	0.3780	Residual	30	1.952 E+10
Prob. > F	0.0008	Total	32	3.138 E+10

Model Parameters	Coefficient	SE	T-stat	P-value
Intercept	314,981	24,656	12.78	0.000
Occupants	1.635893	.554	2.95	0.006
SOC dormitory	19,222	12,767	1.51	0.143

Monthly personnel costs vary with occupancy and new-facility construction:

$$Personnel = \$314{,}981 + \$1.635893 * Occupants + \$19{,}222 * NewSOC\ Facility$$

D.1.3 Support Costs

Approximately 80 percent of monthly support costs are attributable to the credit-card surcharge, which should be directly related to revenue and thus occupancy. A linear relationship is expected, since the surcharge is roughly 3 to 3.5 percent of total monthly revenue. The remaining 20 percent of support costs are fixed monthly surcharges from base services for budgeting and human-relations support. Figure D.5 shows the imperfect linear correlation between support costs and occupancy.

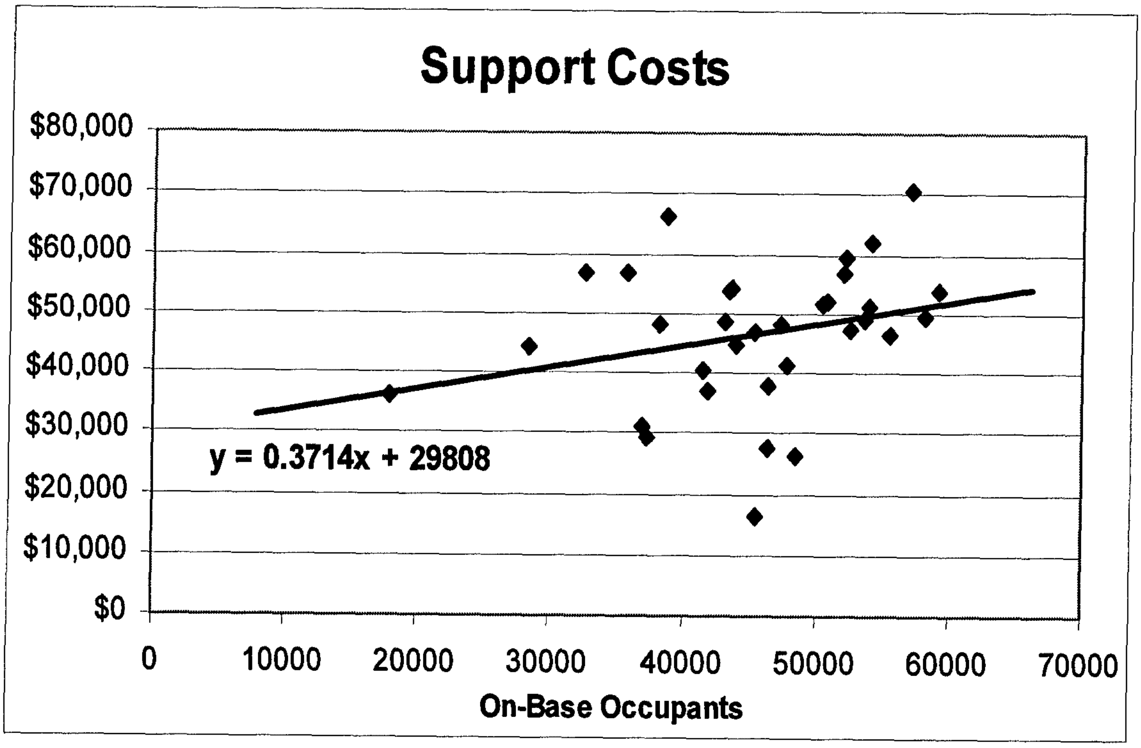


Figure D.5 – Monthly Support Costs Versus Occupancy at Maxwell and Gunter

The most severe outlier at (45,570 occupants, $15,711) occurred in January 2002, when the credit-card expense was only $8,130 despite January revenues of $964,000. This suggests that the period for the monthly credit-card surcharge is not exactly aligned with the month. Lower occupancy and revenues in December 2001, most of which occur at the beginning of December, could explain a lower mid-month charge in January. The monthly credit-card surcharge is not perfectly correlated with either the current-month or previous-month revenues, although a linear relationship exists in both cases. Lacking better data, this analysis estimates total monthly support costs, including the credit-card surcharge, against same-month occupancy statistics.

The credit-card expense should be independent of new-facility construction other than through the linear effect of increased occupancy. It is plausible that the surcharges from base services for budgeting and human-relations support are tied to the number of

facilities.[194] Figure D.6 shows that there is some evidence that support costs may be tied to new-facility construction, since five of the six months after building 681 opened had support costs at or above the monthly average.

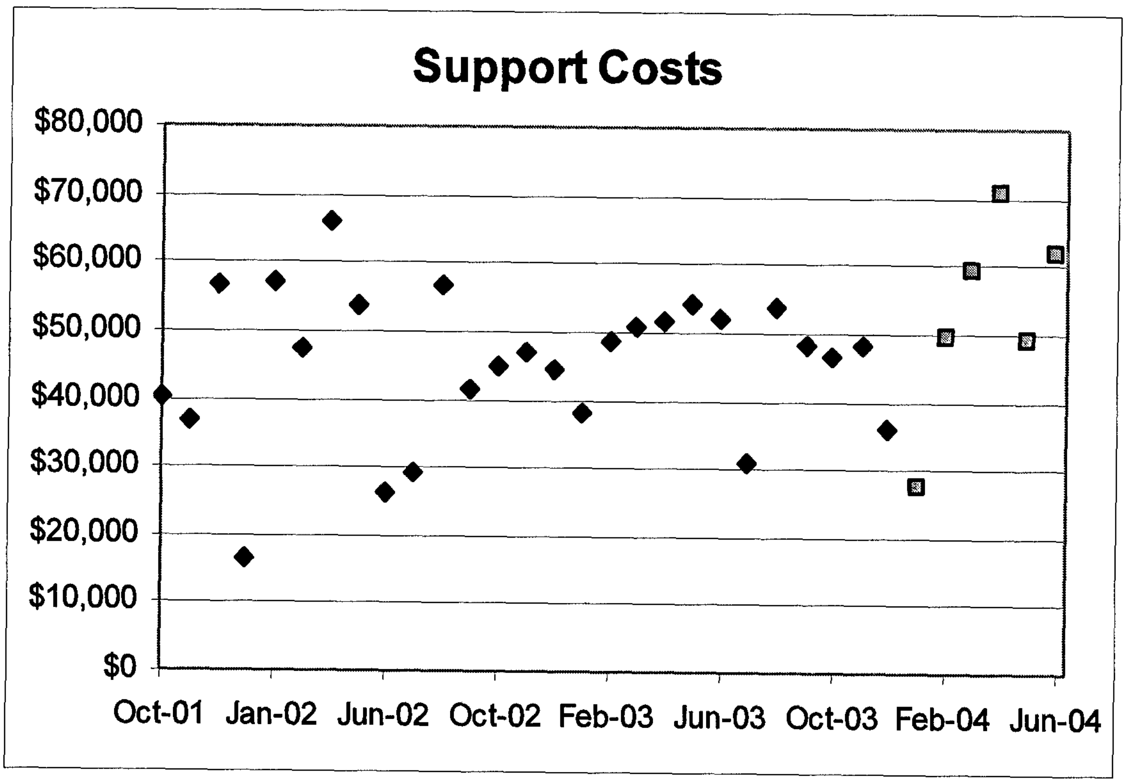


Figure D.6 – Monthly Support Costs at Maxwell and Gunter

[194] The human-relations surcharge is related to the number of personnel hired, trained, administered, and fired by the base services office. Since personnel costs were correlated with new-facility construction beyond the effect of increased occupancy, it is plausible that a new facility would also affect human-relations expenses. However, this effect would be only a small portion of overall support costs.

Table D.2

Support Costs Regressed on Occupants and an SOC Dormitory Dummy Variable

Model Statistics	Value	ANOVA	Df	SS
Observations	33	Regression	2	456562382
R-squared	0.1007	Residual	30	4.0793 E+9
Prob. > F	0.2036	Total	32	4.5358 E+9

Model Parameters	Coefficient	SE	T-stat	P-value
Intercept	33,116	11,272	2.94	0.006
Occupants	0.279	0.253	1.10	0.280
SOC Dorm	4,935	5,837	0.85	0.0405

Controlling for occupancy in the multivariate regression reduces the average monthly cost increase to approximately $5,000, which is not statistically significant.[195] Since there is no convincing theoretical argument for why support costs should markedly increase when a new facility opens, this analysis disregards the facility effect and estimates only the linear occupancy effect:

$$\mathit{Support} = \$29{,}808 + \$.3714188 * \mathit{Occupants}$$

D.1.4 Material Costs

Material costs include supplies, maintenance and repair, expendable equipment, postage, subscription charges, and amenities.[196] Logically, supply usage and facility maintenance should increase with on-base occupancy, but Figure D.7 reveals no apparent linkage. Figure D.7 shows three monthly outliers: February 2003 (43,045 occupants, $173,932); March 2003 (53,956 occupants, –$102,342); and September 2003 (38,097

[195] The number of on-base occupants also becomes insignificant in this regression due to covariate collinearity.

[196] Material costs include expendable equipment that is not amortized (i.e., has less than a two-year useful life or costs less than $2,000).

occupants, $205,937). The negative cost in March rebalances the (likely errant) cost spike in February. Combining these two months yields an average monthly cost of $35,795, only slightly less than the average monthly material cost. The cause of the remaining spike in September 2003 is unknown. It could have resulted from an end-of-year bulk purchase to replenish supply inventory for the upcoming fiscal year.

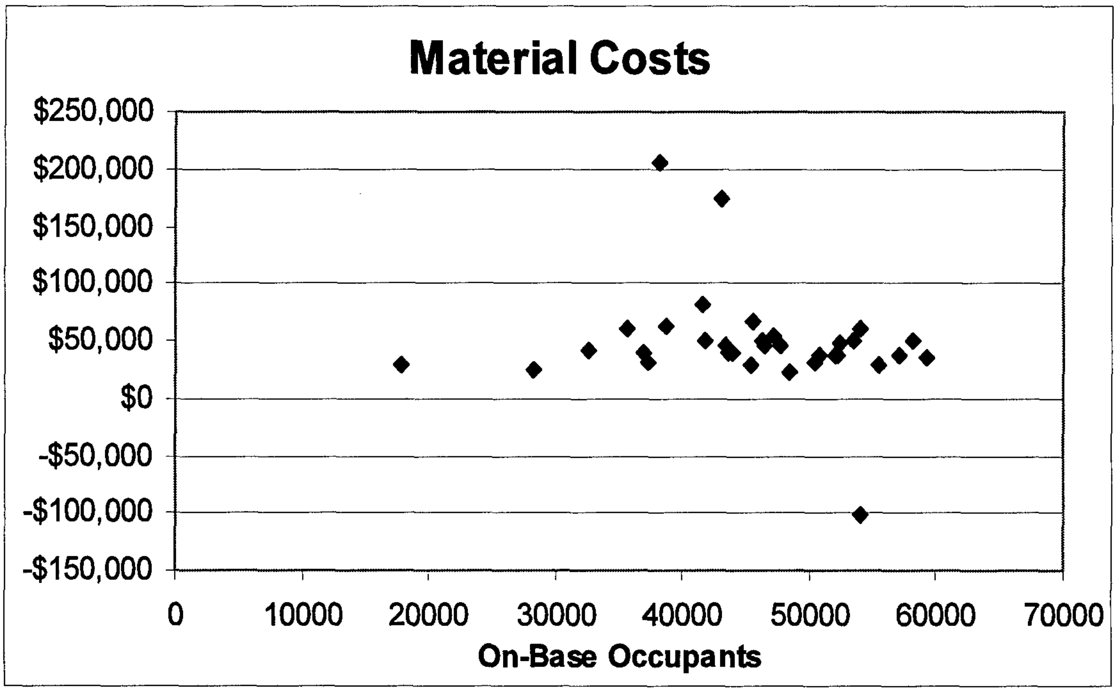


Figure D.7 – Monthly Material Costs Versus Occupancy at Maxwell and Gunter

It is unusual that monthly material costs, which consist largely of supplies, would not increase with increased occupancy. However, the ability to purchase and hold supplies in inventory, in lieu of direct purchases, could disconnect monthly material expenditures from the actual usage of supplies. To evaluate this hypothesis, Table D.3 correlates annual material costs with annual on-base occupancy. Aggregating costs across a larger interval should clarify the relationship between material costs and on-base utilization.

Table D.3
Annual Material Costs Versus On-Base Occupancy

	FY02	FY03	FY04
Material costs ($)	592,348	604,603	526,149
Annual on-base occupants	516,988	539,612	589,115

NOTE: FY04 totals are estimated by inflating 9-month totals to 12-month totals.

While a slight increase in annual material expenditures is correlated with the small increase in on-base occupancy from FY02 to FY03, FY04 expenditures decrease despite a large increase in on-base occupancy. Figure D.7 and Table D.3 imply that the relationship between material costs and on-base occupancy is tenuous or even nonexistent. Additionally, Figure D.8 illustrates that material costs are not affected by the opening of building 681.[197]

[197] Figure D.8 drops the three monthly outliers to show the time series more clearly.

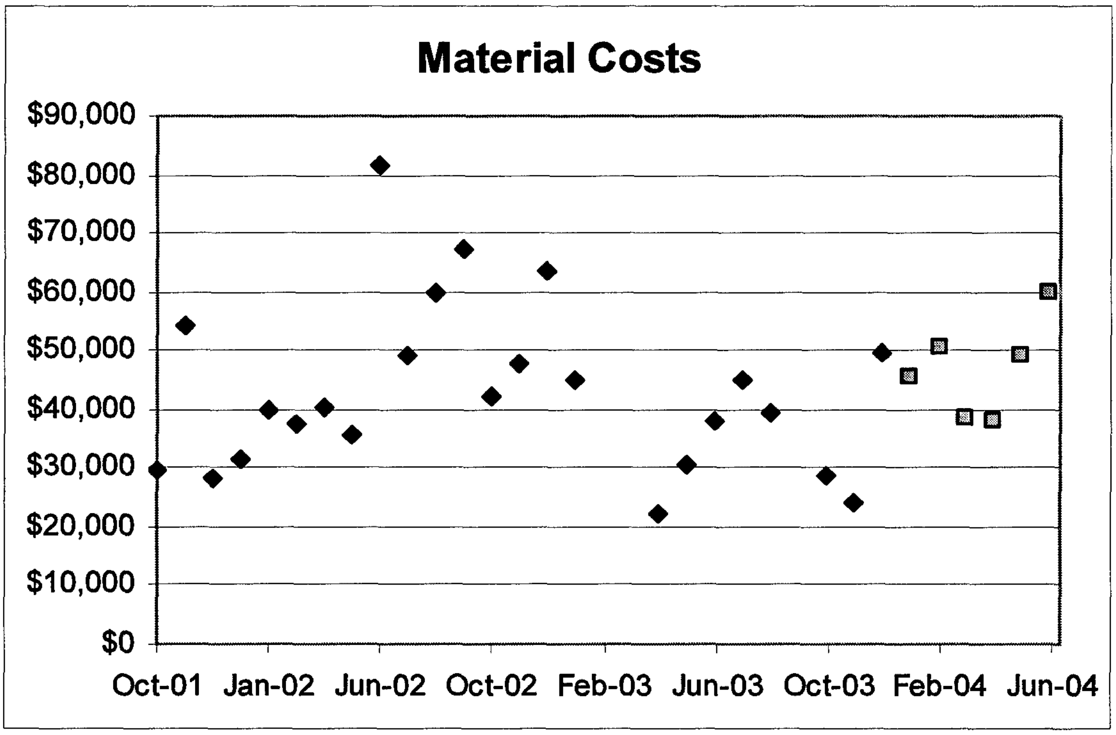


Figure D.8 – Monthly Material Costs at Maxwell and Gunter

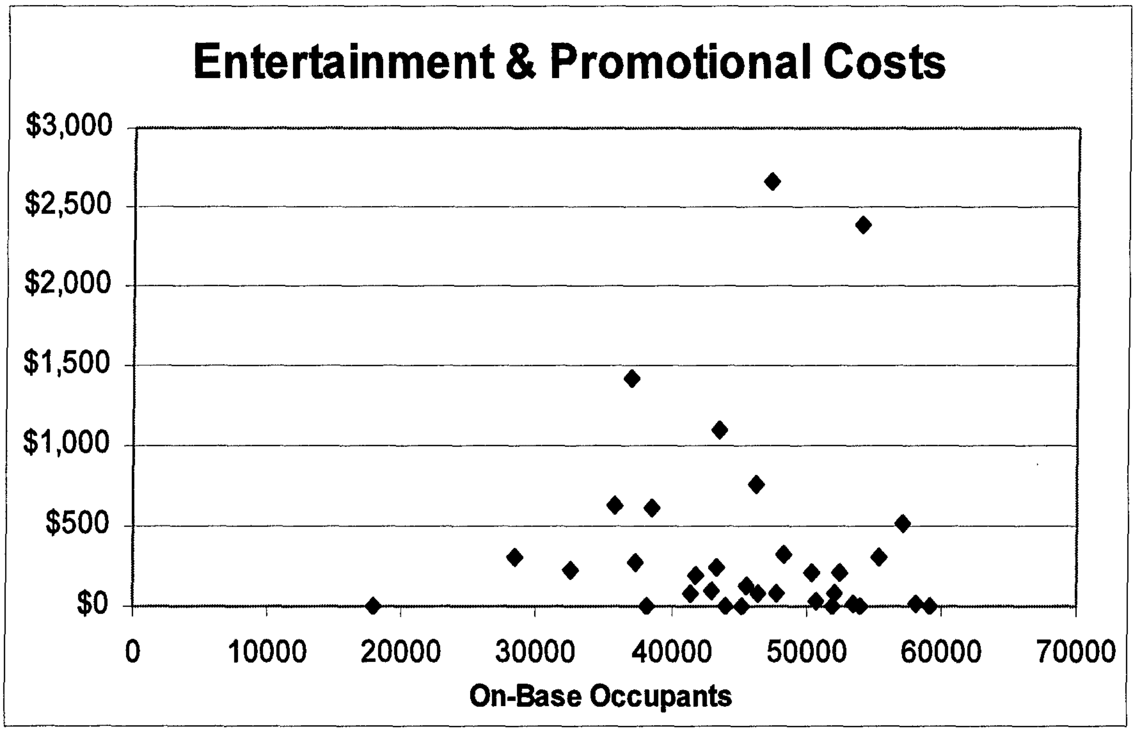
Monthly material costs, estimated by the average monthly expenditure (after dropping the three monthly outliers), are independent of on-base occupancy and new-facility construction, given by:

$$Material = \$43{,}801$$

D.1.5 Entertainment and Promotion Costs

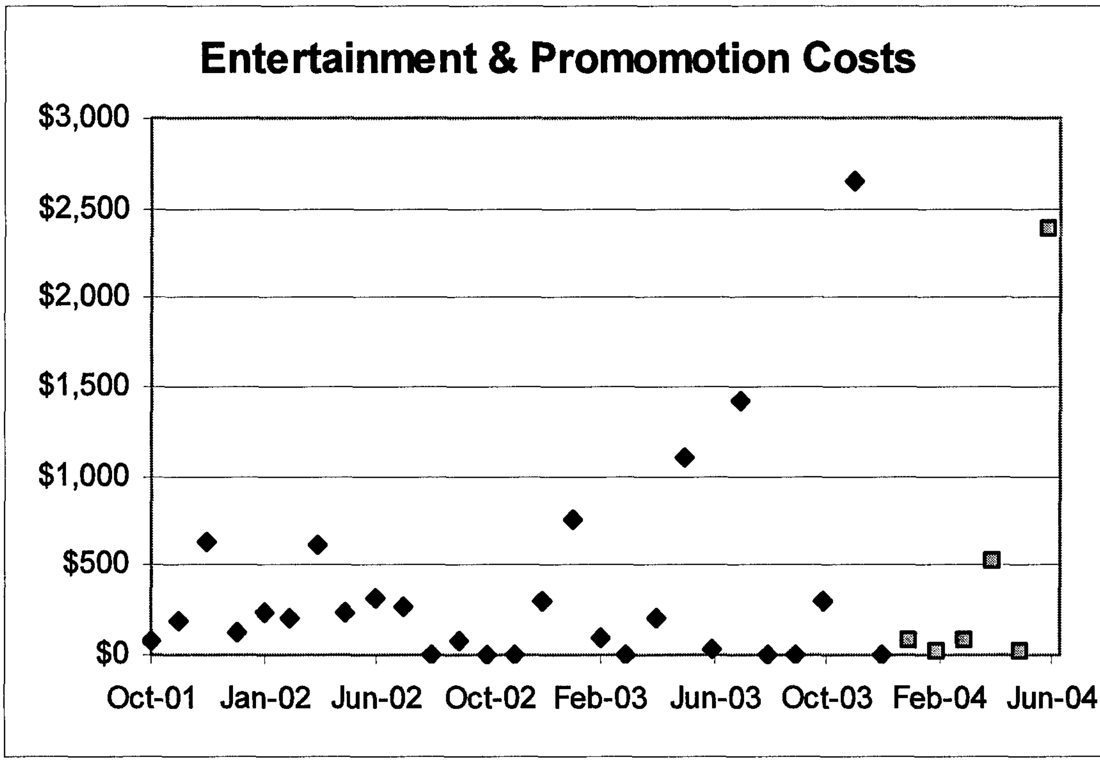
Entertainment and promotion expenses fall into two categories, complimentary items and advertising. Together, they account for a small fraction of overall lodging costs, roughly a few thousand dollars per year. Entertainment and promotion expenses are not correlated with on-base occupancy or new-facility construction (Figures D.9 and D.10) and are estimated by the average monthly expenditure:

$$Entertainment\ \&\ Promotion = \$392$$



NOTE: The two monthly outliers, November 2003 and June 2004, both had uncharacteristic advertising expenses. The outliers do not affect the estimation or model results because of their small relative scale.

Figure D.9 – Monthly Entertainment and Promotional Costs Versus Occupancy at Maxwell and Gunter



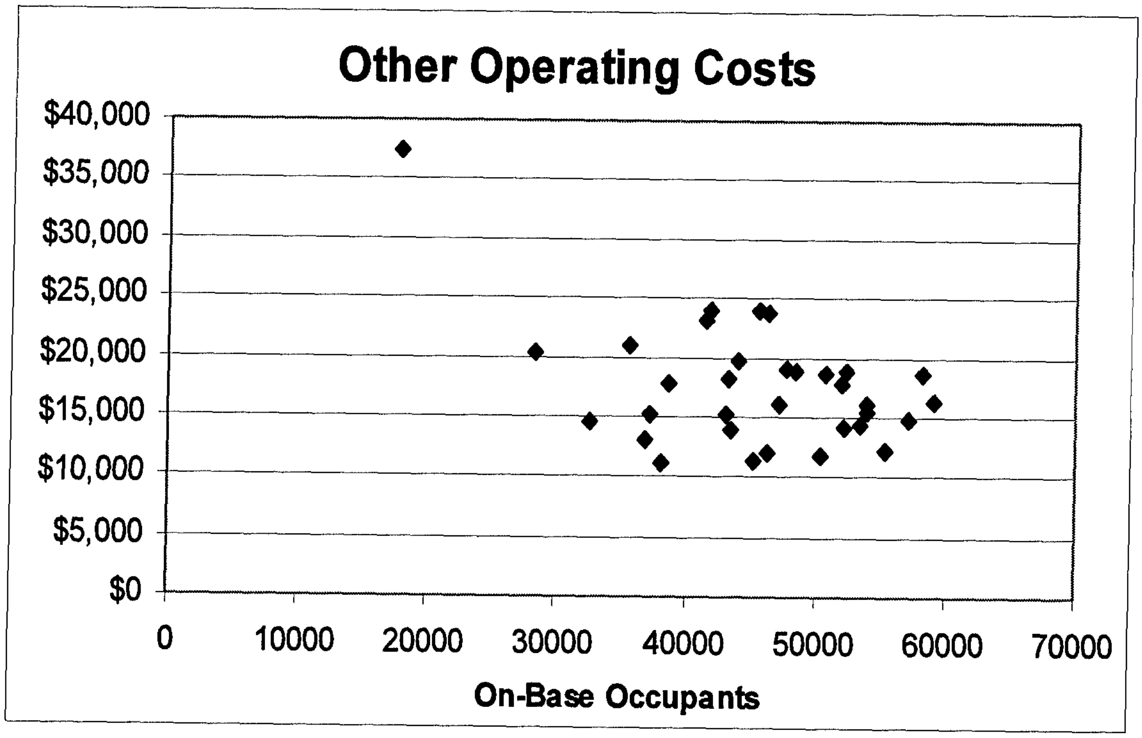
NOTE: The two monthly outliers, November 2003 and June 2004, both had uncharacteristic advertising expenses. The outliers do not affect the estimation or model results because of their small relative scale.

Figure D.10 – Monthly Entertainment and Promotional Costs at Maxwell and Gunter

D.1.6 Other Operating Costs

Other operating expenses consolidate the remaining and miscellaneous expenses: uncollectible returned checks, taxes and license, flowers and decorations, insurance, telephone charges, etc. The largest expense (~80 percent of the total) is telephone service charges, which have been declining slightly over the past three years. Other operating costs were not correlated with occupancy or new-facility construction (Figures D.11 and D.12) and are estimated by the average monthly expenditure:

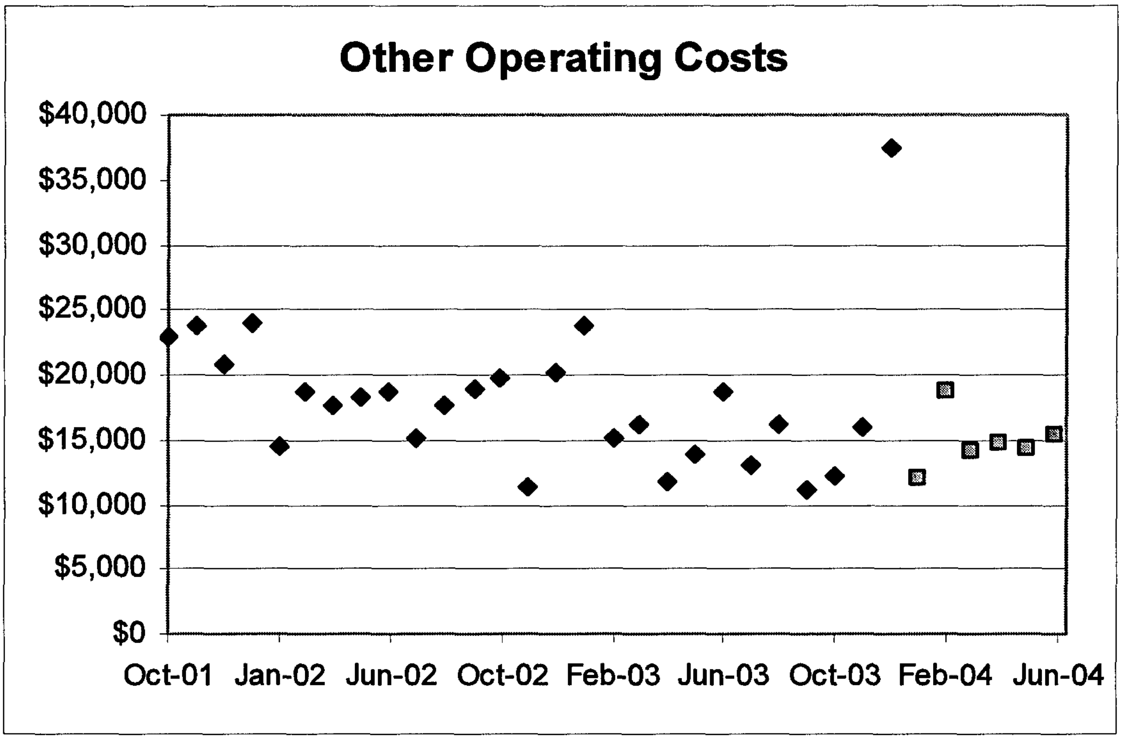
$$\textit{Other Operating} = \$16{,}893$$



NOTE: The outlier, December 2003 (17,826 occupants), had an unspecified $28,000 expense. For all other months, the average unspecified expense was less than $1,000.

Figure D.11 – Monthly Other Operating Costs Versus Occupancy at Maxwell and Gunter

There is some month-to-month variability at each occupancy level, but Figure D.11 does not reveal any trend with respect to occupancy. Average other operating costs are consistent at all occupancy levels. Figure D.12 shows a slight downward trend because of reduced telephone expenses over time; however, the costs appear to have leveled off over the past 17 months. The new SOC facility had no clear effect. Therefore, other operating costs are estimated with the average monthly expenditure.



NOTE: The outlier, December 2003 (17,826 occupants), had an unspecified $28,000 expense. For all other months, the average unspecified expense was less than $1,000.

Figure D.12 – Monthly Other Operating Costs at Maxwell and Gunter

D.1.7 Amortization and Depreciation

The last three line items in the monthly operating statements are not actual executed expenditures for each month. These cost categories account for the monthly amortized and depreciated expenses for large capital expenditures, most of which are for equipment purchased with NAF facility-renovation grants. The distinction between categories has no effect on this analysis because all amortized capital expenditures are captured. For accounting purposes, capital expenditures are typically smoothed over the asset's useful life to avoid impacting the monthly balance sheet in a single month. The resulting monthly cost represents an estimate for the fraction of the capital expenditure paid in that month. The three categories recorded on lodging's monthly operating statements, along with the average monthly expense, are the following:

- **Amortization of expendable equipment.** Expendable equipment is typically equipment that lasts two years or longer and has a cost of $2,000 or more. This includes bulk purchases of VCRs, TVs, vacuum cleaners, etc.:[198]

$$\textit{Amortization Expendable Equipment} = \$44{,}513$$

- **Equipment depreciation.** Heavy equipment is depreciated over a longer term:

$$\textit{Equipment Depreciation} = \$18{,}808$$

- **Facility depreciation.** This category includes only the depreciation of facilities purchased with NAF:[199]

$$\textit{Facility Depreciation} = \$3{,}782$$

Maxwell's lodging operation receives large NAF grants to perform soft-good and hard-good renovations on several facilities each year.[200] Soft-good facility renovations, which include everything in the room except hard furniture, are completed every five years. They include bedspreads, carpeting, drapes, and chairs. Hard-good renovations, or "whole room concepts," are performed every ten years, replacing everything in the room. Maxwell's services office amortizes the items in the NAF grants over their useful lives and records the amortized monthly cost in one of these three categories on the operating statements.[201] The recorded cost in each category does not reflect an actual expenditure but rather a portion of a previous bulk purchase. Therefore, it is not a useful exercise to correlate amortized costs with the monthly occupancy or new-facility construction because they are unrelated. This is not to say that sustained periods of

---

[198] There is a distinction between larger purchases of expendable equipment that are amortized and smaller, expendable-equipment purchases that directly impact the expense statement under material costs.

[199] Since most lodging facilities are constructed with appropriated dollars, this depreciation category includes only lodging-administration facilities and TLFs, and TLFs have been eliminated from this analysis. It is unclear which administrative facility this depreciation applies to, since the lodging administration is located in building 157, a VOQ facility.

[200] The funds for these grants come from retained profits and assessed surcharges from all lodging operations throughout AETC.

[201] The services office uses a program that automatically amortizes/depreciates the expense. Personnel enter the cost and type of item, and the program outputs the amortized monthly cost and term, which are then entered on the monthly expense statements.

higher occupancy would not increase the rate for needed renovations, but that effect cannot be estimated in our data.

Capturing facility-renovation costs is an important part of estimating the overall cost of running a lodging operation. The consolidated monthly figures will provide a good estimate for the annual expense of NAF facility renovations for the current number of facilities. The historical cost data can estimate the amortized renovation costs for only the current facility stock. The additional cost of NAF facility-renovation grants for new facilities will be included in the capital-cost estimates in section D.3.

D.2 APPROPRIATED FUND COSTS

There are two main categories of appropriated funding: government purchase card (GPC) and Air Force Form 9, request for purchase.

D.2.1 Government Purchase Card

The GPC provides appropriated funds to purchase small items for the lodging operation. The annual GPC budget is fixed from year to year, except for inflation adjustment. Total FY03 GPC funds were $110,000. Nominal FY04 GPC totals are $111,600, which equals $109,622 FY03 dollars. This analysis estimates annual GPC costs in FY03 dollars:

$$\textit{Annual GPC Costs} = \$110{,}000$$

D.2.2 Form 9s

Air Force Form 9s are used to request larger appropriated funding purchases, such as linens, laundry services, cleaning supplies, fire-exit signs, carbon-monoxide detectors, office furniture, and paper products (Figure D.13). Some Form 9s, known as fallout Form 9s, receive funding near the end of the fiscal year, when remaining annual

appropriated dollars are dispersed. Fallout Form 9s are included in the cost estimates because they represent an identified mission need, even if the request goes unfunded.

Table D.4
Form 9 Appropriated-Fund Purchases at Maxwell and Gunter
(in dollars)

Appropriated-Fund Purchase	FY03	FY04
General Operating Form 9s		
Fire escape signs	6,000	9,700
Lodging backup supply	5,500	
Landscaping	97,300	
Laundry contract	630,000	650,000
Office furniture	27,300	
Carbon-monoxide detectors	61,000	
Shade cover	6,000	
Linen	308,000	
Toner/copy paper		8,200
Surveillance cameras		5,000
Toilet paper/paper products		73,300
Total	**1,141,100**	**746,200**
Fallout Form 9s		
Cleaning supplies	27,300	
Asst tools	6,100	
Equipment	13,100	
Vacuum cleaners	17,600	
Dial soap	26,500	
Back-up supply	88,000	
Unfunded requests (as of July)		270,000
Total	**178,600**	**270,000**
Form 9 Total	**1,319,700**	**1,016,200**

According to lodging management, FY03 Form 9 funding was unusually high. The biggest factor in the difference between the FY03 and FY04 funding levels is the $308,000 linen funding in FY03. Presumably, this is an infrequent purchase. By

averaging FY03 and FY04 funding levels, this analysis smooths the funding spike across more than one year, yielding a more accurate yearly-funding estimate.[202] There is no evidence that these annual appropriated-funding costs increase with occupancy or additional facilities. Annual appropriated-funding requests may be affected by on-base occupancy or additional facilities, but we did not have enough cost data to justify occupancy- or capacity-based estimates. Despite higher on-base occupancy in FY04 and the opening of the new SOC facility in January 2004, FY04 Form 9 funding levels are below FY03 levels. Therefore, this analysis estimates fixed annual Form 9 appropriated funding.

Table D.5
Form 9 Appropriated-Fund Totals at Maxwell and Gunter

Appropriated-Fund Totals	Cost ($)
FY03	1,319,700
FY04	998,184
Average	**1,158,942**

NOTE: FY04 costs are converted to FY03 dollars for estimation.

Form 9s associated with furnishing the new SOC facility in FY03 are excluded from the estimates for year-to-year appropriated funding. Table D.6 lists the Form 9 funding requests associated with the opening of building 681. These appropriated-funding costs will be used to estimate the cost of furnishing a newly constructed facility in Section D.3.

[202] FY04 totals include actual expenditures through June and projections for the remainder of the year, including fallout funds.

Table D.6
Form 9 Funding for the New SOC Facility in FY03
(in dollars)

SOC Facility Form 9s	FY03
SOC dormitory furnishings	1,406,700
SOC TVs	65,300
SOC dormitory linen	88,600
SOC cookware	20,000
Total	**1,580,600**

The Air Force Form 9 is reproduced in Figure D.13.

REQUEST FOR PURCHASE					NO.
INSTALLATION					DATE
TO: CONTRACTING OFFICER					CLASS
THROUGH:					CONTRACT, PURCHASE ORDER OR DELIVERY ORDER NO.
FROM: *(Insert RC/CC, if applicable)*					
IT IS REQUESTED THAT THE SUPPLIES AND SERVICES ENUMERATED BELOW AND IN THE ATTACHED LIST, BE					
PURCHASED FOR		FOR DELIVERY TO			NOT LATER THAN

ITEM	DESCRIPTION OF MATERIAL OR SERVICES TO BE PURCHASED	QUANTITY	UNIT	ESTIMATED UNIT PRICE	ESTIMATED TOTAL COST
				TOTAL	

PURPOSE		
DATE	TYPED NAME AND GRADE OF REQUESTING OFFICIAL	SIGNATURE TELEPHONE NO.
DATE	TYPED NAME AND GRADE OF APPROVING OFFICIAL	SIGNATURE

I certify that the supplies and services listed above and in the attached list are properly chargeable to the following allotments, the available balances of which are sufficient to cover the cost thereof, and funds have been committed.

ACCOUNTING CLASSIFICATION		AMOUNT
DATE	TYPED NAME AND GRADE OF CERTIFYING OFFICIAL	SIGNATURE

AF IMT 9, 19770301, V2

Figure D.13 – Air Force Form 9

D.3 CAPITAL COSTS

The cost of constructing additional facilities is arguably the most important element in analyzing the cost of different facility-capacity scenarios. The construction cost of preexisting lodging facilities is not included in this analysis because those capital costs are sunk. This section focuses on the cost of investing in a new SOC facility. Constructing and furnishing an additional lodging facility requires an initial investment of $14.6 million (Table D.7). A new facility will incur additional renovation costs beyond those accounted for in the NAF amortization and depreciation costs, which include renovations on only the preexisting facility stock (Section D.1.7). Renovation costs for newly constructed facilities are included in the capital-cost estimates rather than as add-ons to the amortized NAF equipment estimates.

Table D.7
Initial Investment for a New SOC Facility

Funding Category	Cost ($)
Facility construction cost[203]	13,020,383
Building setup cost[204]	1,580,600
Total initial investment	**14,600,983**

While most of the new-facility cost is expensed in the first year, the benefit of that facility is recovered over many years. Consequently, the up-front capital cost and projected future renovation costs should be amortized over the useful life of the facility to convert the total facility cost into a comparable annual expense. The Air Force's target facility recapitalization rate is 67 years, but it would be inappropriate to split the cost evenly over 67 years.[205] This would neglect the real discount rate, which values current

[203] This estimate comes from averaging MILCON construction totals for phase II ($12.6 million in FY02), phase III ($13.4 million in FY04), and program submissions for future phases of the SOC lodging plan ($13.6 million in FY05+). Funding totals were converted to FY03 dollars and averaged.

[204] See Table D.6.

[205] Section 6.3.3 evaluates the effect of a projected facility life of 30 years.

investment and consumption more than future investment and consumption. All present-value calculations in this section utilize the real discount rate of 3.5 percent from OMB circular A-94, Appendix C.

To estimate annualized capital costs, this analysis first calculates the present value of owning an additional facility over the lifetime of the asset. The present-value cost includes the initial investment (see Table D.7) and all projected future soft-good and hard-good replacements discounted to FY03. Figure D.14 illustrates the projected costs of a new facility to be discounted over a 67-year life span.[206]

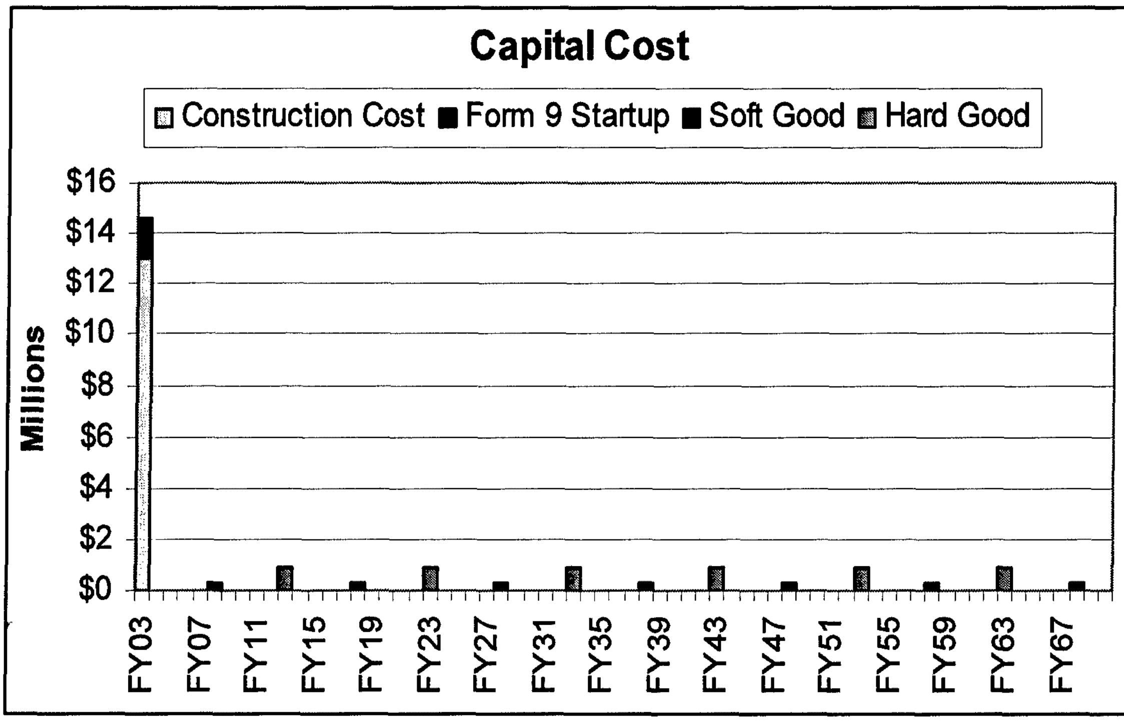


Figure D.14 – New-Facility Initial Investment and Renovation Costs

Soft-good and hard-good renovation costs were estimated from current FY05 renovation projects at Maxwell (Table D.8). The FY05 projects provide comparable renovation projects and estimates for the per-room cost, which can be inflated for the

---

[206] Soft-good replacements are completed every five years; hard-good replacements, every ten years.

162-room SOC facilities. This assumes that renovation costs increase linearly with room count, which seems to be a relatively good assumption because the per-room costs are roughly equivalent between the four hard-good projects with varying room counts. Building 679 is the only facility used to estimate the soft-good renovation costs, but the estimate is good, since building 679 and the new SOC facilities are comparable in size and design. The bolded numbers in Table D.8 are the soft-good and hard-good estimates used in calculating the present-value cost of a new SOC facility in FY03 dollars.

Table D.8
Soft-Good and Hard-Good Renovation Cost Estimates for SOC Facilities

FY05 Renovation Projects	Project Cost (FY03 dollars)	Number of Rooms	Cost Per Room (dollars)	SOC Facility (162 rooms) Cost (dollars)
Soft-Good Renovation				
Bldg. 679	240,292	152	1,581	**256,101**
Hard-Good Renovation				
Bldg. 1016	480,584	90	5,340	865,052
Bldg. 695	332,564	62	5,364	868,959
Bldg. 1417	216,263	40	5,407	875,865
Bldg. 1418	216,263	40	5,407	875,865
Hard-Good Average			5,379	**871,435**

NOTE: FY05 project costs were converted to FY03 dollars, assuming 2 percent annual inflation.

The present-value cost determined from the cash flows in Figure D.14 is divided by the present value of the usable life of the facility to compute a real annual amortized cost. The present-value usable life of a facility is computed by discounting all future useful years to equivalent FY03 years, using the real discount rate. The equation

$\sum_{j=0}^{66} \frac{1}{(1+{}^{i}\!/_{r})^{j}}$ estimates this calculation, where ${}^{i}\!/_{r}$ equals the real discount rate. Table D.9 illustrates an example of this calculation for the first eight years of a facility. The nominal facility years are adjusted for the soft-good and hard-good renovations every five and ten years. The nominal usable years are decreased by one month because the facility renovations prevent a full year's worth of occupancy in those years.

Table D.9
Present-Value Usable Facility Life

Usable Facility Years	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
Nominal	1	1	1	1	1	0.916 7	1	1
Discounted	1	0.966	0.934	0.902	0.871	0.772	0.814	0.786

The real annual amortized cost is computed by dividing the present-value cost by the present value of the usable facility life. This calculation yields a real annualized cost of future phases of the SOC lodging plan of $650,655 (Table D.10).

Table D.10
Capital-Cost Calculation

Funding Category	Nominal Sum Totals	FY03 Present Value
Costs ($)	21,622,301	17,128,066
Useful years	66.917	26.3243
Real amortized annual cost ($)		**650,655**

For illustration, the real amortized annual cost can be spread over the life of the facility by multiplying $650,655 by the discounted usable facility years from Table D.9. Figure D.15 shows how the present-value cost of $17,128,066 is spread over the life of the facility, using the real discount rate. Half of the present-value investment costs are recouped after 18 years, and three-quarters of the costs are recouped after 33 years. This

amortization is the reason the model requires consideration of long-term demand trends and should not be used to estimate costs for temporary high-demand years.

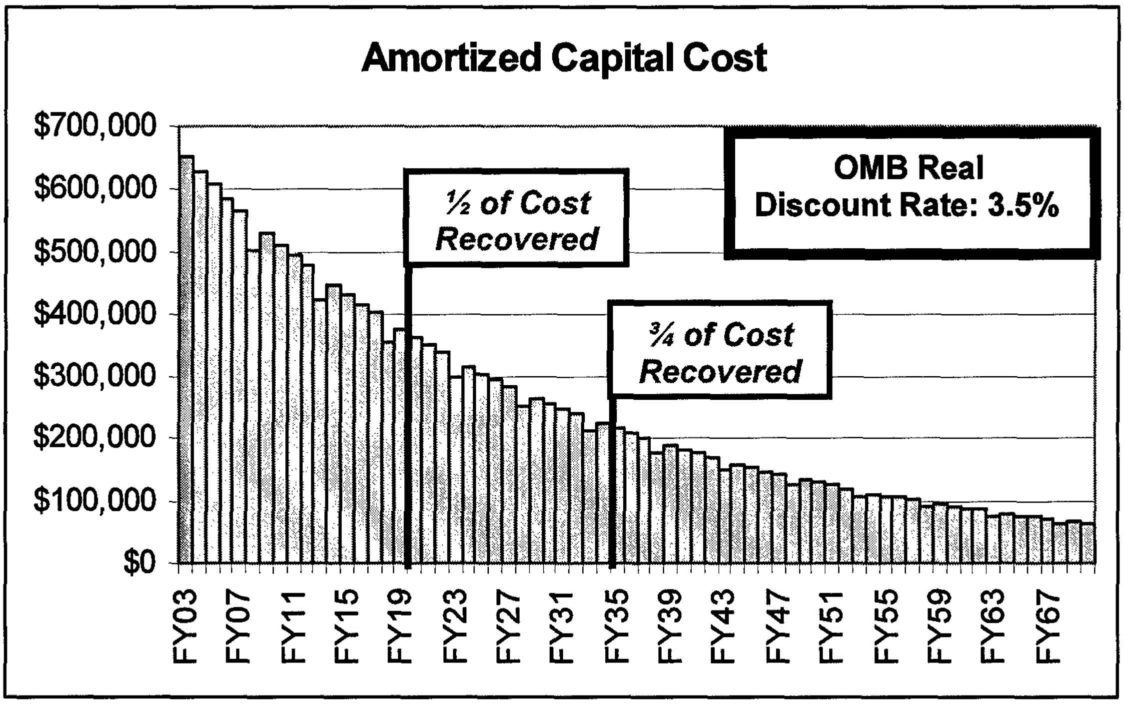


Figure D.15 – Real Amortized Facility Costs Over the Useful Facility Life

If a payback period other than 67 years is desired, this amortization calculation can be adjusted for the chosen facility life. For example, a 30-year payback period is analyzed in Section 6.3.3. In this case, the real annual cost is increased to recoup the entire capital costs in the shorter time frame. The higher annual capital costs alter the costs for each scenario that constructs new facilities and could affect the least-cost capacity recommendations in Chapter 6. To calculate the higher annual amortized cost, we use the methodology discussed above but change the time horizon from 67 to 30 years. Figure D.16 illustrates the projected costs of a new facility over 30 years, and Table D.11 displays the calculation, yielding an annual amortized cost of $843,104.

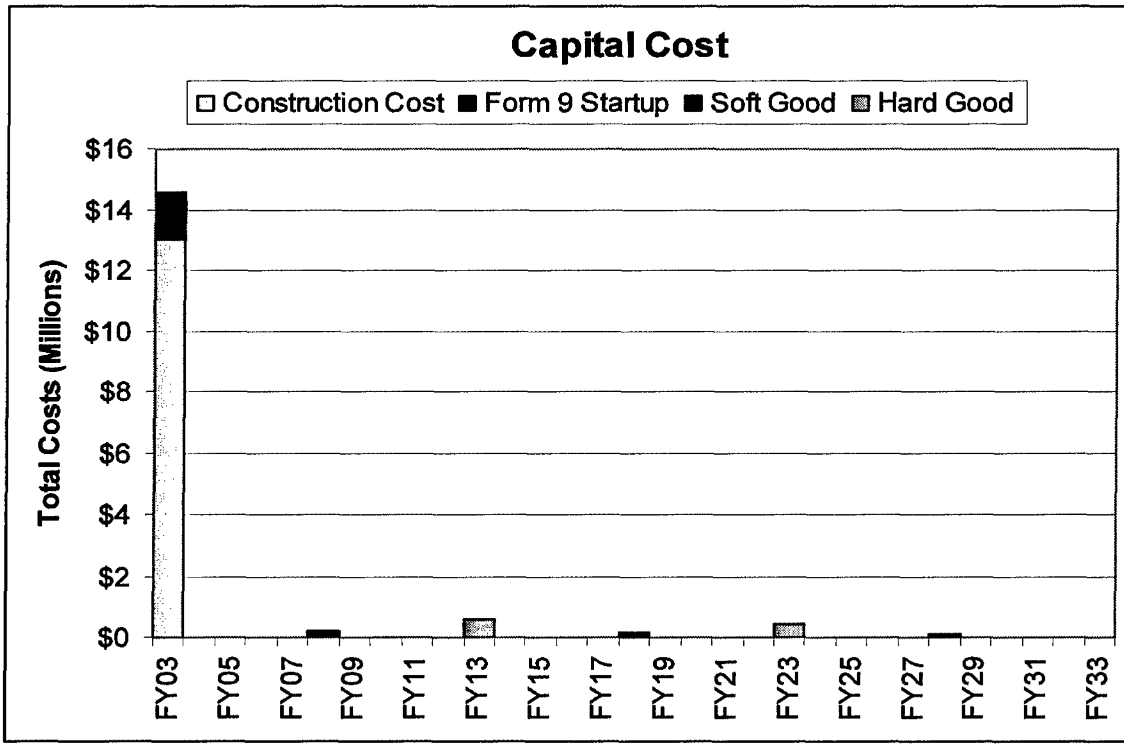


Figure D.16 – New-Facility Initial Investment and Renovation Costs for a 30-Year Life Cycle

Table D.11
Capital-Cost Calculation for 30-year Amortization

Funding Category	Nominal Sum Totals	FY03 Present Value
Costs ($)	17,064,729	16,133,576
Useful years	30.583	19.1359
Real amortized annual cost ($)		**843,104**

For illustration, the real amortized annual cost can be spread over the life of the facility. Figure D.17 shows how the present-value cost of $16,133,576 is amortized over the 30-year life of the facility.

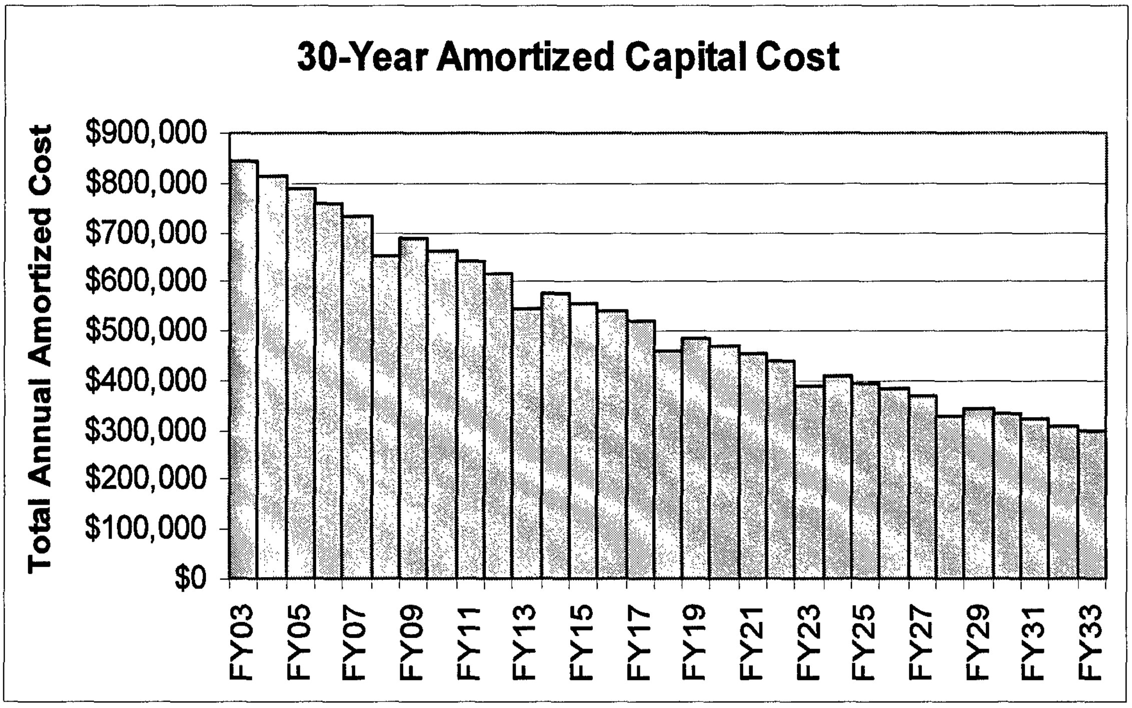


Figure D.16 – Real Amortized Facility Costs Over a 30-Year Useful Facility Life

D.4 CIVIL-ENGINEERING COSTS

In 2001, Maxwell AFB and Gunter Annex outsourced the base operations and support services—functions typically provided by the base civil engineer— to DynCorp. These functions include utilities and major facility maintenance or repair. This section's cost estimates separate the lodging portion of these expenditures from the cost of the basewide contract.

Utility Cost

Utility estimates include the annual cost of electricity, natural gas, and water for all lodging facilities. The lodging facilities are not individually metered, and DynCorp does not record utility usage by facility. However, the enlisted dormitories at Maxwell and

Gunter are individually metered, providing the actual utility usage by facility.[207] The dormitories' utility usage is a good estimate for usage in lodging facilities, although it probably understates lodging's total utility usage.[208] Some lodging facilities have kitchens and therefore use more energy than the single-room dormitories we used for estimation, although the usage by square foot could be approximately equal.

The dormitories' utility costs over a nine and one-half month period from October 1, 2004, to July 13, 2004, are calculated from the facilities' metered records (Table D.12). The total utility costs are then divided by nine and one-half and the total square footage of the dormitories to estimate the average monthly utility usage per square foot. This estimate is combined with the square footage for all lodging facilities to compute an annual-utility-cost estimate. The utility cost for an additional SOC lodging facility (49,852 sq ft) can also be estimated. The available data are not precise enough to capture utility-cost changes related to facility occupancy.

---

[207] Gunter buildings 1410 and 1411 and Maxwell buildings 696, 697, 698, and 849 are included in the estimate, for a total of 152,495 sq ft.

[208] Lodging facilities 695, 697, and 699 are (wholly or partially) converted enlisted dormitories of the same type as those used for the utility estimates.

Table D.12
Lodging-Facility-Utility Estimates

Actual Dormitory Utility Costs (152,495 sq ft)	Cost ($)
Total utility cost (9.5 months)	**149,275**
Electricity	64,174
Natural gas	43,462
Water	41,639
Utility cost/sq ft/month	**0.10304**
Annual lodging estimates	
Total utility cost (838,514 sq ft)	1,036,808
Utility cost for each SOC facility	61,641

The annual utility cost are estimated by the function

$$Utility = \$1{,}036{,}808 + \$61{,}641 * New SOC\ Facility$$

It costs an estimated $1,036,808 to operate all facilities in FY03. Based on the utility cost per square foot, it is expected that each new SOC facility will incur an additional $61,641 of annual utility costs.

Facility Maintenance and Repair Cost

Lodging conducts some maintenance, repair, and upkeep of rooms, but DynCorp conducts the majority of the facility maintenance and repair under contract as the base civil engineer. DynCorp provided facility-specific maintenance and repair cost data from their work-order tracking system, IWIMS.[209] The annual-cost data for FY02 through FY04 were aggregated across all non-TLF lodging facilities to generate annual-total-cost

[209] Interim Work Information Management System.

figures.[210] In addition, IWIMS tracks total facility maintenance and repair costs since 1991, but the costs are not separated by fiscal year or work order.

This analysis compares annual total costs for the past three fiscal years with estimates for the annual averages over the past 14 years obtained from historical data. The historical annual averages are computed by dividing the total FY91–FY04 maintenance and repair costs evenly (in FY03 real dollars) over the 14-year period. Table D.13 compares the actual annual costs from FY02–FY04 with the historical annual estimates. Table D.13 reveals high year-to-year variability and a large difference between the three-year and 14-year annual averages.

Table D.13
Facility Maintenance and Repair Costs
(FY03 Dollars)

	FY02	FY03	FY04	FY02-04 Average	FY91-04 Average
Maintenance and repair costs	3,046,162	1,625,833	2,274,610	2,315,535	1,699,085

NOTE: FY02 costs include two $850,000 projects in buildings 1430 and 1431, which are unusually expensive even for major facility projects.

This analysis requires a consistent annual estimate for the year-to-year operating cost, disregarding yearly fluctuations. As such, it estimates yearly facility maintenance and repair costs by averaging the FY02–FY04 average and the FY91–FY04 average, because there is value in each estimate. The FY91–FY04 estimate provides a long-term historical perspective on annual facility maintenance costs, but the estimate is not based on annualized cost data over that period. It is a projected annual estimate based on the period's total costs. Additionally, the civil-engineering contract was outsourced in 2001, shifting the responsibility for facility maintenance and repair. This makes the more recent DynCorp data a better predictor of future costs than the FY91–FY04 data that

---

210 FY04 estimates projected 10 months' maintenance and repair costs to 12 months.

include Air Force repair data during the 1990s. The FY02–FY04 estimate is based on actual cost data that are more recent and therefore more relevant, but the estimate is noisier because of year-to-year variability.

This analysis is also concerned with how much annual maintenance and repair costs will increase with the addition of a new SOC lodging facility. The cost of maintaining an additional facility is estimated by calculating the annual cost per square foot of maintaining the current facility stock (\$2.3939/sq ft) and multiplying it by the square footage of a new SOC facility (49,852 sq ft). Overall, the annual costs for DynCorp to repair and maintain the lodging facilities are estimated by the function

$$\textit{Maintenance and Repair} = \$2{,}007{,}310 + \$119{,}340 * \textit{NewSOC Facility}$$

In addition to the facility maintenance and repair, DynCorp performs a small amount of minor construction projects on the lodging facilities. IWIMS also records this cost data by facility. Total costs for FY04, the only year available, were \$92,114. Converting this figure to FY03 dollars, the annual estimated cost is

$$\textit{Minor Construction} = \$90{,}481$$

APPENDIX E. QUALITATIVELY ADJUSTING MODEL RESULTS

The simulation model, on average, accounts for 58,541 of the approximately 69,000 actual contract quarters in FY03. The reasons for this understatement were discussed in Section 5.6.2, where it was suggested that the model results could be qualitatively adjusted to ensure that the understatement does not bias facility recommendations. Model results adjusted by increasing contract-quarters dependency and decreasing the effectiveness of on-base facilities were shown in Table 6.3. This appendix outlines the methodology used for this adjustment.

The model's average underestimate is approximately 10,500 contract quarters for the FY03 capacity scenario. This implies a near-equivalent overestimate of on-base occupants, since the model's total-demand levels are consistent with reality (Table E.1).

Table E.1
Simulated Versus Actual Total Demand

FY03 Demand	On-Base Occupants	Contract Quarters	Total Demand
Simulated	549,000	58,500	607,500
Actual	540,000	69,000	609,000
Difference	9,000	(10,500)	(1,500)

To more accurately reflect reality, we decrease the number of on-base occupants and increase the number of contract quarters. For simplicity, both adjustments are equal to the difference between actual and simulated contract-quarters totals, 10,500 bed spaces. For example, the number of simulated FY03 on-base occupants is reduced from 549,000 to 538,500 to reflect the underestimated 10,500 contract-quarters occupants. The decreased on-base occupancy results in a cost savings of $20,793. This total comes from the marginal on-base NAF cost estimate of $1.9878434 for each overestimated on-base occupant. The number of contract quarters is directly increased by 10,500, from 58,500 to 69,000. Annual contract-quarters costs are increased by $54 for each additional off-base occupant, yielding an increase of $564,840. The adjusted total

lodging cost is computed by subtracting the on-base cost savings from the additional contract-quarters costs. Total lodging cost thus increased by $544,047 for the FY03 capacity scenario.

Similarly, contract quarters are increased and on-base occupancy is decreased to adjust the costs for the other capacity scenarios. However, the model's contract-quarters underestimate will not be 10,500 for all capacity scenarios. As additional facilities are added, an increased facility supply will lead to fewer total off-base occupants, which in turn should reduce the model's contract-quarters underestimate. To make adjustments to the other scenarios, we assume that the underestimated contract quarters decrease in proportion to the overall decrease in contract quarters between scenarios (Table E.2).[211] For example, the construction of phase II (one additional facility) reduced the average contract-quarters totals to 55 percent of the totals without phase II (32,089 vs. 58,541). This proportion is used to calculate the underestimate for the phase II scenario (55%*10,500 = 5,734). The on-base/off-base occupancy and total costs are then adjusted using the underestimates shown in Table E.2, using the same methodology described above.

Table E.2
Projected Contract-Quarters Underestimate, by Capacity Scenario

Contract Quarters	FY03	+1 Facility	+2 Facilities	+ 3 Facilities	+ 4 Facilities
Simulated totals	58,540	32,089	13,498	4,254	1,115
Totals as percentage of FY03 total	-	54.82%	23.06%	7.27%	1.90%
Projected contract-quarters underestimate	10,460	5,734	2,412	760	199

NOTE: The last two capacity scenarios (+ 5 and + 6 facilities) are excluded from the table for ease of presentation.

211 This assumption seem plausible, since the model's underestimate is due to simplifying modeling assumptions and would likely be proportionally consistent with the total contract quarters across scenarios.

BIBLIOGRAPHY

AETC Supplement 1 to AFI 34-246, "Air Force Lodging Program," HQ AETC/SVX, 21 May 2002.

Air Force Instruction 34-246, "Air Force Lodging Program," HQ USAF/ILV, 17 May 2001.

Air Force Instruction 65-106, "Appropriated Fund Support of Morale, Welfare, and Recreation (MWR) and Nonappropriated Fund Instrumentalities (NAFIs)," SAF/FM, 1 October 2002.

Air University Course Catalog, http://www.au.af.mil/au/catalogs.php.

Angelus A., and E. Porteus, "Simultaneous Production and Capacity Management Under Stochastic Demand for Produced to Stock Goods," Graduate School of Business Research Paper No. 1419R, Stanford University, Stanford, CA, 2000.

Angelus A., E. Porteus, and S. Wood, "Optimal Sizing and Timing of Modular Capacity Expansions," Graduate School of Business Research Paper No. 1479R2, Stanford University, Stanford, CA, 2000.

Arrow, K., T. Harris, and J. Marschak, "Optimal Inventory Policy," *Econometrica*, Vol. 19, No. 3, July 1951, pp. 250–272.

Arrow, K., S. Karlin, and H. Scarf, *Studies in the Mathematical Theory of Inventory and Production*, Stanford University Press, Stanford, CA, 1958.

Axsater, S., *Inventory Control*, Kluwer Academic Publishers, Boston, MA, 2000.

Berman, O., Z. Ganz, and J. Wagner, "A Stochastic Optimization Model for Planning Capacity Expansion in a Service Industry Under Uncertain Demand," *Naval Research Logistics*, Vol. 41, 1994, pp. 545–564.

Browne, S., and P. H. Zipkin, "Inventory Models with Continuous Stochastic Demand," *The Annals of Applied Probability*, Vol. 1, 1991, pp. 419–435.

Bullet Background Paper on SOC phase III MILCON, 22 OCT 02.

Dahlman, C., R. Kerchner, and D. Thaler, *Setting Requirements for Maintenance Manpower in the U.S. Air Force*, RAND Corporation, Santa Monica, CA, MR-1436-AF, 2002.

Daniel, K., "A Delivery Lag Inventory Model with Emergency," Chapter 2 in H. Scarf, D. Gilford, and M. Shelley (eds.), *Multistage Inventory Models and Techniques*, Stanford University Press, Stanford, CA, 1963.

Eppen, G., R. Kipp Martin, and L. Schrage, "A Scenario Approach to Capacity Planning," *Operations Research*, Vol. 37, No. 4, July–August, 1989, pp. 517–527.

Evans and Chastain, L.L.P., "Keesler AFB Needs Assessment Study Visitors Quarters," June 2003.

"Facilities Recapitalization Front-End Assessment," Department of Defense, Washington, DC, August 2002.

Federgruen, A., and P. Zipkin, "An Efficient Algorithm for Computing Optimal (s, S) Policies," *Operations Research*, Vol. 32, No. 6, November–December, 1984, pp. 1268–1285.

Fries, B., "Optimal Ordering Policy for a Perishable Commodity with Fixed Liftetime," *Operations Research*, Vol. 23, No. 1, January–February, 1975, pp. 46–61.

Fukuda, Y., "Optimal Policies for the Inventory Problem with Negotiable Leadtime," *Management Science*, Vol. 10, No. 4, July 1964, pp. 690–708.

Gaimon, C., "Subcontracting Versus Capacity Expansion and the Impact on Pricing of Services," *Naval Research Logistics*, Vol. 41, 1994, pp. 875–892.

Hall, R., "Chronic Excess Capacity in U.S. Industry," NBER Working Paper No. 1973, National Bureau of Economic Research, Cambridge, MA, 1986.

Hillier, F., and G. Lieberman, *Introduction to Operations Research*, 7th ed., McGraw Hill, New York, 2001.

Iglehart, D., "Optimality of (s, S) Policies in the Infinite-Horizon Dynamic Inventory Problem," *Management Science*, Vol. 9, 1963, pp. 259-267.

Johansen, S., and R. Hill, "The (r,Q) Control of a Periodic-Review Inventory System with Continuous Demand and Lost Sales," *International Journal of Production Economics,* Vol. 68, 2000, pp. 279–286.

Johansen, S., and A. Thorstenson, "An Inventory Model with Poisson Demands and Emergency Orders," *International Journal of Production Economics*, Vol. 56-57, 1998, pp. 275–289.

Johansen, S., and A. Thorstenson, "Optimal (r, Q) Inventory Policies with Poisson Demand and Lost Sales: Discounted and Undiscounted Cases," *International Journal of Production Economics*, Vol. 46, 1996, pp. 359–371.

Lamontagne, Lt. General Don, "AU-21: Air University's Production Challenges," briefing slides, FY01.

Lau, H., and A. Lau, "The Newsstand Problem: A Capacitated Multiple-Product Single-Period Inventory Problem," *European Journal of Operational Research*, Vol. 94, 1996, pp. 29–42.

Lian, Z., and L. Liu, "A Discrete-Time Model for Perishable Inventory Systems," *Annals of Operations Research*, Vol. 87, 1999, pp. 103–116.

Luss, H., "Operations Research and Capacity Expansion Problems: A Survey," *Operations Research*, Vol. 30, Issue 5, September–October, 1982, pp. 907–947.

Manacapilli, T., B. Bennett, L. Galway, and J. Weed, *Air Education and Training Command Cost and Capacity System: Implications for Organizational and Data Flow Changes,* RAND Corporation, Santa Monica, CA, MR-1797-AF, 2004.

Manne, A., "Capacity Expansion and Probabilistic Growth," *Econometrica*, Vol. 29, Issue 4, October 1961, pp. 632–649.

Mattock, Michael G., *Optimal Commercial Satellite Leasing Strategies*, RAND Corporation, Santa Monica, CA, MR-1402-AF, 2002.

"Maxwell AFB General Plan", undated.

McCullagh, P., and J. A. Nelder, *Generalized Linear Models*, Chapman and Hall, London, 1989.

Memorandum for HQ AETC/CE on FY05 MILCON program call, undated.

Nahmias, S., "Perishable Inventory Theory: A Review," *Operations Research*, Vol. 30, No. 4, July–August, 1982, pp. 680–708.

Nam, S., and R. Logendran, "Aggregate Production Planning – A Survey of Models and Methodologies," *European Journal of Operational Research*, Vol. 61, 1992, pp. 255–272.

Neebe, A., and M. Rao, "The Discrete-Time Sequencing Expansion Problem," *Operations Research*, Vol. 31, No. 3, May–June, 1983, pp. 546–558.

Neuts, M., "An Inventory Model with an Optional Time Lag," *SIAM*, Vol. 12, No.1, March 1964, pp. 179–185.

"The Report of the Department of Defense on Base Realignment and Closure," Department of Defense, Washington, DC, April 1998.

Scarf, H., "Bayes Solutions of the Statistical Inventory Problem," *Annals of Mathematical Statistics*, Vol. 30, No. 2, June 1959, pp. 490–508.

Scarf, H., "The Optimality of (S, s) Policies in the Dynamic Inventory Problem," in *Mathematical Methods in the Social Sciences*, K. Arrow, S. Karlin, and P. Suppes (eds.), Stanford University Press, Stanford, CA, 1960, pp.196–202.

Silver, E., D. Pyke, and R. Peterson, *Inventory Management and Production Planning and Scheduling*, 3rd edition, John Wiley & Sons, New York, 1998.

Veinott, A., "On the Optimality of (s, S) Inventory Policies: New Conditions and a New Proof," *SIAM Journal on Applied Mathematics*, Vol. 14, No.5, September 1966, pp. 1067–1083.

Veinott, A., "The Status of Mathematical Inventory Theory," *Management Science*, Vol. 12, Issue 11, July 1966, pp. 745–777.

Veinott, A., and H. Wagner, "Computing Optimal (s, S) Inventory Policies," *Management Science*, Vol. 11, No. 5, March 1965, pp. 525–552.

Weisstein, Eric W., "Bin-Packing Problem," *MathWorld*—A Wolfram Web Resource, http://mathworld.wolfram.com/Bin-PackingProblem.html.

Williams, C., and B. Patuwo, "A Perishable Inventory Model with Positive Order Lead Times," *European Journal of Operational Research*, Vol. 116, 1999, pp. 352–373.

Wooldridge, J., *Introductory Econometrics: A Modern Approach*, South-Western College Publishing, 2000.

Zabel, Edward, "A Note on the Optimality of (S, s) Policies in Inventory Theory, *Management Science*, Vol. 9, No. 1, October 1962, pp. 123–125.